FINAL DRAFT FEBRUARY 17, 1999

Guidelines and Specifications for Flood Map Production Coordination Contractors

Appendices and References

Federal Emergency Management Agency
500 C Street, SW. • Washington, DC 20472
www.fema.gov

Appendix A

List of Acronyms

The following acronyms will be encountered by the FMPCC throughout these *Guidelines* and in the completion of NFIP-related tasks:

A

AAER	Average Annual Erosion Rate
ASCE	American Society of Civil Engineers
ASCII	American Standard Code for Information Interchange
ASFPM	Association of State Floodplain Managers

B

BERD	Blocked Erosion Rate Database
BFE	Base Flood Elevation

C

CADD	Computer-Assisted Drafting Design
CBRA	Coastal Barrier Resources Act (of 1982)
CBRS	Coastal Barrier Resources System
CCO	Consultation Coordination Officer
CD-ROM	Compact Disk Read-Only Memory
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
CID	Community Identification (Number)
CIS	Community Information System
CLOMA	Conditional Letter of Map Amendment
CLOMR	Conditional Letter of Map Revision
CLOMR-F	Conditional Letter of Map Revision Based on Fill
CMA	Community Map Action (Form)

CRS	Community Rating System
CO	Contracting Officer
CRS	Community Rating System
CSIS	Credited Structures Inventory System
CTC	Cooperating Technical Community

D

DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DLG	Digital Line Graph
DLG-3	Digital Line Graph Level 3
DOI	U.S. Department of the Interior
DOQ	Digital Orthophoto Quadrangle
DTM	Digital Terrain Model

E

EDR	External Data Request
E-FIRM	Erosion Zone Flood Insurance Rate Map
EPA	U.S. Environmental Protection Agency
ERM	Elevation Reference Mark
ESDP	Engineering Study Data Package
ESDPF	Engineering Study Data Package Facility
ETJ	Extraterritorial Jurisdiction Limits
E-ZBD	Erosion-Zone Boundary Database

F

FBFM	Flood Boundary and Floodway Map
FCSA	Fee-Collection System Administrator
FEDD	Flood Elevation Determination Docket
FEMA	Federal Emergency Management Agency

FFED	Final Flood Elevation Determination
FGDC	Federal Geographic Data Committee
FHAR	Flood Hazard Analyses Report
FHBM	Flood Hazard Boundary Map
FIPS	Federal Information and Processing Standards
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMPCC	Flood Map Production Coordination Contractor
FOIA	Freedom of Information Act
FPI	Floodplain Information Report

G

GIS	Geographic Information System
GPO	U.S. Government Printing Office

H

HEC	Hydrologic Engineering Center (U.S. Army Corps of Engineers)
H&H	Hydrologic and Hydraulic Analyses
HQ	Headquarters (FEMA)
HSLD	Historic Shoreline Location Database
HSPCD	Historic Shoreline Positional Change Database
HWL	High Water Line

L

LAG	Lowest Adjacent Grade
LAN	Local Area Network
LFFE	Lowest Finished Flood Elevation
LIDEF	Levee Inventory Data Entry Form
LMMP	Limited Map Maintenance Program
LODR	Letter of Determination Review

LOMA	Letter of Map Amendment
LOMC	Letter of Map Change
LOMC-VALID	Letter of Map Change Revalidation (Letter)
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision Based on Fill

M

MHWL	Mean High Water Line
MSC	Map Service Center
MICS	Monitoring Information on Contracted Studies (System)
MIS	Management Information System
MNUSS	Map Needs Update Support System

N

NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NFIF	National Flood Insurance Fund
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act of 1994
NGVD29	National Geodetic Vertical Datum of 1929
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Survey
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSSDA	National Standard for Spatial Data Accuracy

O

ODC	Other Direct Cost

OPA	Otherwise Protected Area

P

PDF	Portable Document Format
PMR	Physical Map Revision
PO	Project Officer

Q

QC	Quality Control

R

RCFH	Revision Case File Header
RFIS	Flood Insurance Restudy
RMM	River Mile Marker
RO	Regional Office (FEMA)
RPO	Regional Project Officer
RXDS	Existing Data Restudy

S

SC	Study Contractor
SCERSR	Study Contractor Erosion Rate Study Report
SCRR	Special Conversion Recommendation Report
SCS	U.S. Soil Conservation Service
SDTS	Spatial Data Transfer System
SFHA	Special Flood Hazard Area
SOMA	Summary of Map Actions
SOS	Status of Studies
SOW	Statement of Work
SPR	Special Problem Report
SWFL	Stillwater Flood Level

T

T&C	Time & Cost
TCS	(Standard Flood Hazard) Tracking and Correspondence System
TIGER	Topologically Integrated Geographic Encoding and Reference (System)
TIN	Triangulated Irregular Network
TMAC	Technical Mapping Advisory Council
TSDN	Technical Support Data Notebook
TVA	Tennessee Valley Authority

U

USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
USGS-DLG	U.S. Geological Survey Digital Line Graph (Format)
UTM	Universal Transverse Mercator

W

WSEL	Water-Surface Elevation

X

XDS	Existing Data Study

Appendix B

Specifications for Preparing Maps and Graphics

The specifications the FPMCC must apply in the preparation of FIRMs and the graphics included in FIS reports are available in hard copy format only. Interested parties may obtain a copy of the specifications, free of charge, by submitting a request to the FEMA Mitigation Directorate at the following address on the Internet: mapmod@fema.gov.

Appendix C

Preparation of Reports

This appendix outlines requirements and standards that the FMPCC shall use in preparing initial and revised FIS reports for printing by GPO. Unless the FMPCC is directed to do otherwise by the PO or his/her designee, a revised FIS report shall be prepared in the format of the existing FIS report. Specific requirements and standards for such reports are presented in Subsection C.1.1.

On occasion, the PO or his/her designee may direct the FMPCC to reformat a revised FIS report by retyping the text and, in most cases, placing the text and graphics in either the Map Initiatives or Countywide Format (using information from several published FIS reports). The specific requirements and standards that shall be applied to reformatted FIS reports are presented in Subsection C.1.2.

Regardless of the format used, the FIS report shall include the following: text; cover; vicinity map; tables; photographs (if available); profiles, floodway schematic; and, when necessary, transect schematic and transect location map. The FMPCC shall ensure that the report is organized as outlined in *Flood Insurance Study Guidelines and Specifications for Study Contractors* (Reference 1).

C.1 Text Format

The FMPCC shall follow the requirements below concerning the text format and organization for all revised FIS reports.

- The margins of all pages shall be approximately 1 inch to allow for binding of the printed report.
- The following material shall be typed on a separate page and appear before the first page of the Table of Contents:

Notice to Flood Insurance Study Users

> **Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.**
>
> **Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with**

community officials and to check the community repository to obtain the most current FIS components.

- If the addendum format is used, the following information shall be included in the Notice to Flood Insurance Study Users:

  This publication incorporates revisions to the original Flood Insurance Study. These revisions are presented in Section 9.0 (Section 10.0).

- For situations where the FIRM for a community is being prepared, in whole or in part, in the Map Initiatives Format, the FMPCC shall include the following information at the end of the Notice To Flood Insurance Study Users:

  Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone(s)	New Zone
Al through A30	AE
VI through V30	VE
B	X
C	X

- For situations in which the ERM descriptions are located both in the FIS report and on the FIRM, the FMPCC shall 'place the following paragraph in Section 3.2:

  All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation Reference Marks (ERMs) used in this study are shown on the maps. Descriptions of some marks are shown directly on selected Flood Insurance Rate Map panels; the remaining descriptions are presented in Elevation Reference Marks (Exhibit 3).

- The final camera-ready text shall be typed, single-spaced, on 8-1/2″ × 11,″ good-quality, nongrain paper. Negatives of the text are not required for the camera-ready delivery.

C.1.1 Revised Reports

If the report is not reformatted, the format, organization, and content of the revised text shall follow that of the existing text, with some exceptions. For guidance in preparing such reports, the FMPCC shall refer to "Policies and Procedures for Flood Map Production Coordination Contractors for Processing Flood Insurance Study Revisions," dated May 13, 1986 (Reference 16).

The FMPCC shall take the most cost-effective approach to updating the FIS report; however, the minimum work required shall be the creation of an additional section that shall be placed at the end of the FIS report. This section, entitled "Revisions Description," shall provide information regarding the significant revisions that were made since the FIS report was last printed. A subsection shall be included for each revision and shall be numbered consecutively (e.g., 9.1, 9.2, for reports prepared in Standard Format; 10.1, 10.2, for reports prepared in Map Initiatives Format).

C.1.2 Reformatted Reports

C.1.2.1 Map Initiatives Format

If a report is to be retyped in the Map Initiatives Format, the format, organization, and content shall follow that of the sample FIS report provided in Subsection C.4 and the outline provided in *Flood Insurance Study Guidelines and Specifications for Study Contractors* (Reference 1). Significant requirements concerning format and organization are provided below.

- The following paragraph shall be completed and substituted for the first paragraph in Section 1.1 of the report:

  This Flood Insurance Study report has been prepared to revise and update a previous Flood Insurance Study/Flood Insurance Rate Map for the Full Community Name. This information will be used by Community Name to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

- The tables listed below are to be typed as part of the text; hence, they require no graphics preparation. The required tables may differ according to the type of flooding covered by the FIS (riverine, lacustrine, tidal, or any combination). They may be produced in a landscape or portrait format, with preference given to the best presentation based on the size of the tables.

  Summary of Discharges—riverine studies

  Summary of Elevations—lacustrine studies

  Transect Locations, Summary of Stillwater Elevations, and Initial Wave Crest Elevations—coastal studies

- As stated in Appendix B, ERM descriptions shall be provided on the FIRM. However, some effective FIRMs prepared in the Map Initiatives Format do not contain ERM descriptions. The descriptions for these FIRMs were instead included in the accompanying FIS reports. Refer Appendix B for a discussion of how such descriptions shall be treated when the FIS report and FIRM are revised.

C.1.2.2 Existing Data Studies/Existing Data Restudies

The FMPCC shall prepare the report for an XDS or RXDS in accordance with "Federal Emergency Management Agency Guidelines and Specifications, Existing Data Studies," dated September 2, 1982 (Reference 17).

C.1.2.3 Countywide Format

The FMPCC shall use the same basic format standards in preparing the typewritten text in the Countywide Format as those provided in Subsection C.4; however, several changes shall be made to the standard wording and tables. Those changes are presented below in the order of their appearance in the FIS report.

- Section1.1—The first paragraph shall be revised to read as follows:

> **This Flood Insurance Study revises and supersedes the Flood Insurance Study reports and/or Flood Insurance Rate Maps in the geographic area of ______________ County, State, including the Complete Names of Incorporated Communities, in Alphabetical Order, and unincorporated areas of __________ County (hereinafter referred to collectively as _________ County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by ________ County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.**

- Section 2.1—The first sentence shall read as follows: "This Flood Insurance Study covers the geographic area of ___________ County, State."
- Section 6.0—The following paragraph shall be added at the end of the section if the report is prepared in Map Initiatives Format:

> **The current Flood Insurance Rate Map presents flooding information for the entire geographic area of ________ County. Previously, separate Flood Insurance Rate Maps were prepared for each identified floodprone incorporated community and the unincorporated areas of the county. Historical data relating to the maps prepared for each community are presented in Table ___.**

- Community Map History Table—Information for this table shall be presented in the format shown in Appendix B.

C.2 Graphics

C.2.1 Cover

The FMPCC shall use the existing cover of the FIS report if it was prepared according to the specifications given in Appendix B, for restudies and revisions in the Standard and Map Initiatives

Formats, and the Countywide Format. The following requirements should be emphasized concerning presentation of the final cover:

- The revised date (same as that on the FIRM) shall be shown on the camera-ready copy.
- The legal name of the community (e.g., City of _________, Township of ______), county name, and State name shall be shown on the cover. The legal name may be obtained from the *National Flood Insurance Program Community Status Book*, or from the FEMA CIS.
- If the FIS report is to be printed in two or more volumes, a separate cover shall be prepared for each volume, indicating the appropriate number of the volume. (See Appendix B.)

If the FMPCC creates a new FIS report, the cover need not include the outline of the subject county and State. The final, camera-ready cover shall be provided on 9″ × 12″ contact negative film.

C.2.2 Vicinity Map

The FMPCC shall use the existing vicinity map frame if it was prepared according to the specifications given in Appendix B. The final vicinity map shall be submitted on 9″ × 12″ contact negative film. If a new FIS report is created by the FMPCC, a vicinity map shall not be created. Corporate limits of existing vicinity maps will not be revised for annexations.

C.2.3 Transect Location Map

For studies or restudies that include wave height or wave runup analyses, the locations of the transects used in the analyses shall be shown on an appropriate map. When a transect location map is required, the frame shall be prepared according to the specifications given in Appendix B. The final transect location map shall be submitted on 9″ × 12″ contact negative film.

C.2.4 Flood Photographs

If flood photographs are to be used in the FIS report, the FMPCC shall submit the screened photographs set in their correct locations in the FIS report. The photographs shall be prepared in positive or negative camera-ready form.

C.2.5 Floodway Schematic and Other Figures

Typically, the floodway schematic and area other figures shall be spliced into the text pages or imported into position electronically.

C.2.6 Tables

C.2.6.1 Floodway Data Table

Floodway data shall be tabulated in a Floodway Data Table for each cross section shown on the FIRM or Flood Boundary and Floodway Map. Cross-section labels shall be consistent with the work maps and Flood Profiles. The WSELs in the "Regulatory" column shall be identical to the elevations shown on the Flood Profiles. The "Without Floodway" column shall contain the natural base flood WSELs of streams computed without consideration of backwater from other flooding sources. Thus, these two columns will contain identical elevations except in confluence situations where regulatory elevations are determined by another flooding source.

Cross-section data may be shown for areas of backwater flooding; however, elevations in the "Without Floodway" column shall be footnoted as follows: "Elevation Computed Without Consideration of Backwater Effects From (Source of Flooding)." The words "Backwater Effects" should be replaced with "Tidal Effects," "Overflow Effects," "Ice Jam Effects," or "Storm Surge Effects," to reference the appropriate flooding situation.

Where a rise in energy grade has been used to determine the regulatory floodway, the computed change in WSEL shall be shown, even though these changes may be small. When negative surcharges are encountered, the "Increase" column shall be shown as 0.0, and the value in the "With Floodway" column shall be the same as the value in the "Without Floodway" column. In general, when bridge cross-section data are included in the table, only the data for the cross section at the upstream face of the bridge should be provided in the table.

The floodway width values shown on the Floodway Data Table shall be rounded to the nearest whole foot. When a part of a floodway is outside the corporate or county limits and the width within the corporate or county limits is not shown, the "Width" column shall be footnoted as follows: "This Width Extends Beyond the Corporate/County Limits." When both the total width and the width within the corporate/county limits are known, the "width" column shall be footnoted as follows: "Width/Width Within Corporate (County) Limits."

The specifications for the Floodway Data Table are provided in Appendix B.

C.2.6.2 Flood Insurance Zone Data Table

For FIS reports prepared in the Standard Format, flood insurance zone data shall be tabulated at the direction of the PO. Flood insurance zone data shall be included in the appropriate format for each flooding source studied by detailed methods. However, backwater reaches of a tributary stream shall not be listed when the main stream has also been studied and zone data are listed for it in the table. The specifications for the Flood Insurance Zone Data Table are provided in Appendix B.

In situations where the FIRM is being produced, in whole or in part, in the Map Initiatives Format, the FMPCC shall remove the Flood Insurance Zone Data Table from the FIS report.

C.2.7 Flood Profiles

The Flood Profiles for each stream studied by detailed methods shall be drawn in standard format, using the format, symbol, and type specifications shown on the sample Flood Profile in Appendix B. If a main stream has backwater effects on a tributary stream, and the flood elevations computed for the main stream are revised, the Flood Profiles for the tributary stream shall be revised accordingly. The Flood Profiles shall be prepared using the guidelines outlined in *Flood Insurance Study Guidelines and Specifications for Study Contractors* (Reference 1). Additional information concerning Flood Profiles that should be considered is provided in the following subsections. The FMPCC shall note, however, that the following exceptions to standard processing of Flood Profiles may be made:

- PROFPLOT or comparable software that may be used to prepare the flood profiles if the HEC-2 model is available on computer diskette.
- Flood profiles generated by SCs or revision requesters may be used for final publication if they are technically accurate and legible.
- When flood profiles are created for the first time, the 10-, 50-, and 500-year flood lines need not be included.
- When revising existing Flood Profiles, the FMPCC need not redraft the 10-, 50-, or 500-year flood lines. If this action results in the revised 100-year flood line being located below the 10- or 50-year flood line or above the 500-year flood line, the FMPCC shall delete the 10-, 50-, and 500-year flood lines, as necessary.

C.2.7.1 Cross Sections

Cross sections for each stream shall be labeled in alphabetical sequence, beginning at the downstream study limit. Each stream should begin with A, B, C, and continue to Y, Z, AA, AB, … AZ, BA, BB, BC, and so forth. Cross-section sequences shall not be carried over from one stream to another unless the hydraulic model is continuous from one stream to another. Cross-section labels shall be shown within hexagonal shapes; when close spacing necessitates, hexagons shall be stacked, as shown on the sample profile in Appendix B. The location of the cross section indicated by the placement of the hexagon must not deviate more than 0.05 inch from the location presented in the floodway data table. For short stream segments that meander beyond the detailed study limits, and for stream segments for which no regulatory floodway is computed, selected sequentially labeled cross sections may be shown on the Flood Profile.

C.2.7.2 Plotting of Sources

Flood Profiles shall not be plotted for more than one flooding source on each panel, with one exception. When a main stream goes by one name to a point where it is formed by the confluence of two small tributary streams, one of the tributary streams shall be selected as a logical continuation of the main stream. The profile shall then continue, uninterrupted, up the tributary. The profile panel shall show both the stream names in the title block and shall indicate the point where the name change occurs. The main stream stationing and cross-section sequencing shall continue up the tributary stream. Each stream shall be treated separately in the text and tables.

C.2.8 Tables, Figures, and Profiles in Countywide Format

For FIS reports prepared in the Countywide Format, the community name information presented in the title block for all graphics with frames shall appear in the following format:

COUNTY, <u>STATE ABBREVIATION</u> AND INCORPORATED AREAS

The type specifications shall be the same as those presented in Appendix B.

C.3 Volume Printing

All FIS reports exceeding 150 pages in length shall be subdivided into two or more volumes. No more than 100 pages shall be included in any volume. Where possible, reports shall be subdivided so that volumes begin and end at logical breakpoints; however, the number of volumes shall be minimized. One listing, entitled “Tables of Contents,” shall be prepared for all volumes. A copy of the complete Tables of Contents shall appear in each volume. The format to be followed for the Tables of Contents is provided in a memorandum dated October l6, 1984, entitled “Policy for Implementation of Printing FIS Report Texts by Volumes” (Reference 18).

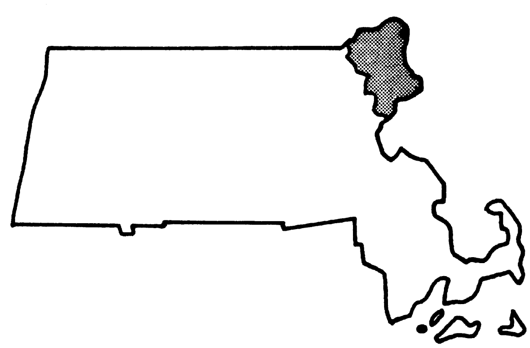
C.4 Sample Report

The following sample FIS report, for a fictional Massachusetts community, is in the final form to be produced by the FMPCC. The sample FIS report is for a community subject to both riverine flooding *and* coastal flooding (wave height and runup hazards). This FIS report has been prepared in the Map Initiatives Format.

FLOOD INSURANCE STUDY

TOWN OF FLOODPORT, MASSACHUSETTS

FLOOD COUNTY



Federal Emergency Management Agency

COMMUNITY NUMBER - 259999

NOTICE TO
FLOOD INSURANCE STUDY USERS

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FLOOD INSURANCE STUDY
TOWN OF FLOODPORT, FLOOD COUNTY, MASSACHUSETTS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Town of Floodport, Flood County, Massachusetts, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by John Brown Engineering Corporation, for the Federal Emergency Management Agency (FEMA), under Contract No. H-0123. This work was completed in December 1985.

1.3 Coordination

The initial Consultation and Coordination Officer (CCO) meeting was held on April 12, 1983, and attended by representatives of FEMA, the Town of Floodport, and the study contractor.

Coordination with Town officials and Federal, State, and regional agencies produced information pertaining to floodplain regulations, community maps, flood history, and other hydrologic data.

The U.S. Army Corps of Engineers (COE) and the National Oceanic and Atmospheric Administration (NOAA) were contacted for data on tide elevations. Coordination with these agencies concerning coastal flood elevations was continued during the study. The Massachusetts Department of Public Works (MDPW) was contacted for information on historic flooding and high-water marks. Vertical control data used to establish the network of elevation reference marks were provided by the MDPW, NOAA, U.S. Geological Survey (USGS), and U.S. Coast and Geodetic Survey.

An intermediate CCO meeting was held on February 14, 1984, and attended by representatives of FEMA, the community, and the study contractor. The purpose of this meeting was to present preliminary results of the study to the community.

The results of the study were reviewed at the final CCO meeting held on December 1, 1986, and attended by representatives of FEMA, the community, and the study contractor. All problems raised at that meeting have been addressed in this study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the Town of Floodport, Flood County, Massachusetts. The area of study is shown on the Vicinity Map (Figure 1).

Riverine flooding on the Mill River from approximately 100 feet downstream of U.S. Route 1 to the upstream corporate limits was studied by detailed methods. Tidal flooding from the Atlantic Ocean, including wave action, and the Merrimack River was also studied by detailed methods.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through December 1990.

Keiths and Richards Creeks were studied by approximate methods for their lengths within the Town of Floodport.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the Town of Floodport.

2.2 Community Description

The Town of Floodport is located in northeastern Flood County, in northeastern Massachusetts, approximately 35 miles north of the City of Boston. It is bordered by the Atlantic Ocean to the east; the Town of Rowley to the south; the Towns of West Newbury, Groveland, and Georgetown to the west; and the City of Newburyport to the north.

Because of its proximity to the Atlantic Ocean, Floodport attracts both a permanent and transient population. According to the 1980 State census, the town had an estimated population of 4,239, a 10.2-percent increase from the estimated 1965 population of 3,845.

Vicinity Map for subject community should appear here.

(Note: The Town of Floodport, Massachusetts, is fictional, so no map is shown.)

Figure 1. Vicinity Map

The population density in 1980 was 167 persons per square mile (Reference 1). Floodport is experiencing growth pressure, and coastal seasonal homes are being converted to year-round residences. It is estimated that the population of the town will increase approximately 51 percent by 1990 (Reference 2).

The total area contained within the corporate limits of Floodport is 25.4 square miles. Of the total area, only 8.4 percent is classified as urban land. The remaining land uses are as follows: forest, 34.6 percent; wetlands, 38.2 percent; agriculture and open land, 16.8 percent; mining and waste disposal, 0.3 percent; and recreation, 1.7 percent (Reference 3).

Development along the Floodport coast is primarily residential (permanent and seasonal) and recreational. The coast is characterized by the sand dunes of the barrier beach, Plum Island, which extends form the confluence of Plum Island Sound and the Ipswich River north to the Merrimack River. Residential development is located on the northern portion of Plum Island. The remainder of Plum Island, except for Camp Sea Haven, is part of the Parker River National Wildlife Refuge. To the west of Plum Island is an extensive system of salt marshes associated with the Mill and Plum Island Rivers. The Plum Island River, a tidal creek, is a waterway for small boats between the Merrimack River and Plum Island Sound. Residential development is located west of the salt marshes, approximately 2 miles from the coast. Residential development is also located in the southwestern corner of town.

The coast is relatively flat, ranging from sea level to an approximate elevation of 30 feet. Inland, the topography is level, with an average elevation of 50 feet. Small hills, with elevations of 100 to 150 feet, are located in the southern and southwestern portions of town. The soils are predominantly wet throughout eastern and central Floodport. Northwestern Floodport has rough and stony soils. Floodport has a tidal shoreline of 48.3 miles (Reference 4).

The Mill River and its tributaries drain most of the town. The river, which is 21 miles long and has a drainage area of approximately 35 square miles, has its headwaters in West Boxford and flows northeasterly until it joins Plum Island Sound in Floodport.

The climate of Floodport is variable. The average annual precipitation is approximately 43 inches; the average annual snowfall is approximately 47 inches. The Floodport area experiences no dry season. From June to September, rainfall usually occurs as showers or thunderstorms. The thunderstorms produce heavy, sometimes excessive, amounts of rain. Throughout the year, the heaviest gales usually come from the northeast and east and are more common and severe during the winter. “Northeasters,” as they are called, produce an abundance of rain and snow. The average annual temperature is approximately 51°F; the mean temperatures for January and July are 28°F and 74.8°F, respectively (Reference 5).

2.3 Principal Flood Problems

The low-lying coastal areas of the town adjacent to the Atlantic Ocean are subject to the periodic flooding and wave attack that accompanies storms such as northeasters. Hurricanes have not produced significant flooding in these areas. The majority of coastal storms cause damage only to low coastal roads, boats, beaches, and seawalls. Occasionally, a major storm accompanied by strong onshore winds and high tides results in surge and wave activity that causes extensive property damage and erosion.

Four of the more significant storms in the Floodport area were those of December 1901 and 1959 (approximately 160- and 15-year recurrence intervals, respectively) and February 1972 and 1978 (approximately 10- and 70-year recurrence intervals, respectively). These storms damaged harbors, marinas, and residential and commercial developments in the floodprone coastal areas.

In addition to flooding, serious shorefront erosion has occurred at Plum Island since the early 1880s, when the mouth of the Merrimack River was located approximately 0.5 mile south of its present position. Jetties, which were constructed at the turn of the century, had stabilized the entrance of the river at its present location and tended to create a buildup of the oceanfront shores on the northern end of the island.

However, since 1938, continuous recession of the shoreline has occurred, resulting primarily from severe storm surge and coincident wave action. During the severe storm that occurred on February 19, 1972, a wide fronting beach and backlying dunes were destroyed, and several cottages were damaged or destroyed. This storm made the island susceptible to further damage.

Riverine flooding had not generally been as severe as coastal flooding in the Floodport area. Extreme water levels on the Mill River are primarily caused by runoff from heavy rainfall and snowmelt.

2.4 Flood Protection Measures

Present and future demands associated with the seasonal tourist industry will further intensify the pressure for development of flood-prone coastal lands. However, the adoption of State and local development regulations concerning floodplain management will help alleviate storm-related losses (Reference 6).

No major structural flood protection measures exist or are planned for the Town of Floodport.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, *average* period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Floodflow frequencies for the Mill River were based on a statistical analysis of USGS gage data. These data were analyzed in accordance with criteria outlined in Bulletin 17B (Reference 7). Discharge-frequency data were based on a USGS computer model (Reference 8). The model was run on November 20, 1983, using a systematic record of 32 years and a generalized skew coefficient; the input for, and assumptions of, the analysis were reviewed and accepted for use in this study.

Peak discharge-drainage area relationships for the Mill River are shown in Table 1.

In New England, the flooding of low-lying coastal areas is caused primarily by storm surge generated by extratropical coastal storms called northeasters. Hurricanes also occasionally produce significant storm surge in New England, but they do not occur nearly as frequently as northeasters.

To calculate the storm surge and total storm tide elevations produced by historic storms, storm pressures and windfields were determined. A computer model was developed to simulate these fields based on several easily obtained storm parameters of northeasters. A detailed description of this model is presented in the report entitled

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cubic feet per second) 10-Year	50-Year	100-Year	500-Year
Mill River					
At U.S. Route 1	13.6	415	685	831	1,261

Development and Verification of a Synthetic Northeaster Model for Coastal Flood Analysis (Reference 9). A different model was used to simulate the windfields and pressures of the hurricanes considered in this analysis (Reference 10). When coupled with a computer surge model, the storm tide along the shoreline could be calculated for each storm of interest.

NOAA synoptic weather charts were searched to determine the northeasters and hurricanes that could potentially produce significant flooding in the Floodport area (Reference 11). Tidal records from tide gages in the New England area were examined to verify which historic storms produced high-water elevations. For the analysis of flood levels, 165 storms, occurring from 1942 to 1978, were considered.

The flood levels associated with historic storms were simulated using a modified version of the FEMA storm surge model (References 12 and 13). Input to the model consisted of windfield and pressures generated either by the synthetic northeaster model or a hurricane-windfield-and-pressure-field model for each historic storm selected. The study area was modeled using a square grid of sufficient resolution to accurately represent the offshore bathymetry and shoreline configuration. The grid mesh covered an area from Cape Cod Bay to north of Portsmouth, New Hampshire, including Boston Harbor. Output from the model included the time history of storm-induced stillwater elevations for the communities in the study areas. The total stillwater elevation was calibrated using historic tide elevation data at Boston, Massachusetts, and Portsmouth, New Hampshire. Thus, the historic storm-induced flood levels in Floodport could be simulated for each storm considered in the analysis.

The extent and frequency of coastal flooding were determined by conducting a frequency analysis of annual minimum tidal heights along the Atlantic coast at Floodport. Some historic storm-tide heights, consisting of both an astronomical tide and a storm-surge contribution, were determined by the mathematical simulation of historic northeasters and hurricanes described above; others, for which associated storm data were not available, were obtained by a correlation analysis using tide data from Boston or Portsmouth. The database at the Boston gage extended discontinuously from 1848 to 1978; the shorter record at Portsmouth was lengthened by a statistical correlation with data at Boston and Portland, Maine.

The annual maximums of these reproduced historic water elevations were fitted with a log-Pearson Type III distribution.

Elevations for floods of the selected recurrence intervals for the Atlantic Ocean and the Merrimack River are shown in Table 2.

The analyses reported in this study reflect the stillwater elevations due to tidal and wind setup effects. The effects of wave action were also considered in the determination of flood hazard areas. A detailed description of the methodology

Table 2. Summary of Stillwater Elevations

Flooding Source and Location	Elevation (Feet) 10-Year	50-Year	100-Year	500-Year
Atlantic Ocean				
Entire Shoreline Within Floodport	8.2	8.9	9.2	9.8
Merrimack River				
Entire Shoreline Within Floodport	5.9	7.2	8.2	8.9

employed in this analysis can be found in a report entitled "Determination of Coastal Storm Tide Levels" (Reference 13). Coastal structures that are located above stillwater flood elevations can still be severely damaged by wave runup, wave-induced erosion, and wave-borne debris. For example, during a northeaster in February 1978, considerable damage along the Massachusetts coast was caused by wave activity, even though most of the damaged structures were above the highwater level.

The extent of wave runup past stillwater levels depends greatly on the wave conditions and local topography.

Wave heights and corresponding wave crest elevations were determined using the methodology developed by the National Academy of Sciences (NAS) (Reference 14). The wave runup was determined using the methodology developed for FEMA by Stone and Webster Engineering (Reference 15).

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross sections for the backwater analyses were obtained from topographic maps compiled from aerial photographs (Reference 16). Below-water sections were obtained by field surveys. All bridges and culverts were surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 17). Starting water-surface elevations for the Mill River were determined using critical depth.

Channel and overbank roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the stream and floodplain areas. The channel "n" values for the Mill River ranged from 0.015 to 0.050, and the overbank "n" values ranged from 0.015 to 0.050.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Hydraulic analyses, considering storm characteristics, the shoreline, and bathymetric characteristics of the tidal flooding source studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The COE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 18). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood-frame or brick-veneer structures.

A wave height analysis was performed to determine wave heights and corresponding wave crest elevations for the areas inundated by tidal flooding. A wave runup analysis was performed to determine the height and extent of runup beyond the limit of tidal inundation. The results of these analyses were combined into a wave envelope, which was constructed by extending the maximum wave runup elevation seaward to its intersection with the wave crest profile.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the NAS (Reference 14). The NAS methodology is based on three major concepts. First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where H_b is the crest-to-trough height of the maximum or breaking wave and d is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S_* + 0.7H_* = S_* + 0.55d$$

where Z_w is the wave crest elevation, S_* is the stillwater elevation at the site, and H_* is the wave height at the site. The 0.7 coefficient is the portion of the wave height that reaches above the stillwater elevation. H_b is the upper limit for H_*.

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

where H_t is the transmitted wave height, B is a transmission coefficient ranging from 0.0 to 1.0, and H_i is the incident wave height. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine the transmission coefficient for vegetation, buildings, natural barriers such as dunes, and manmade barriers such as breakwaters and seawalls (Reference 14).

The third major concept concerns unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

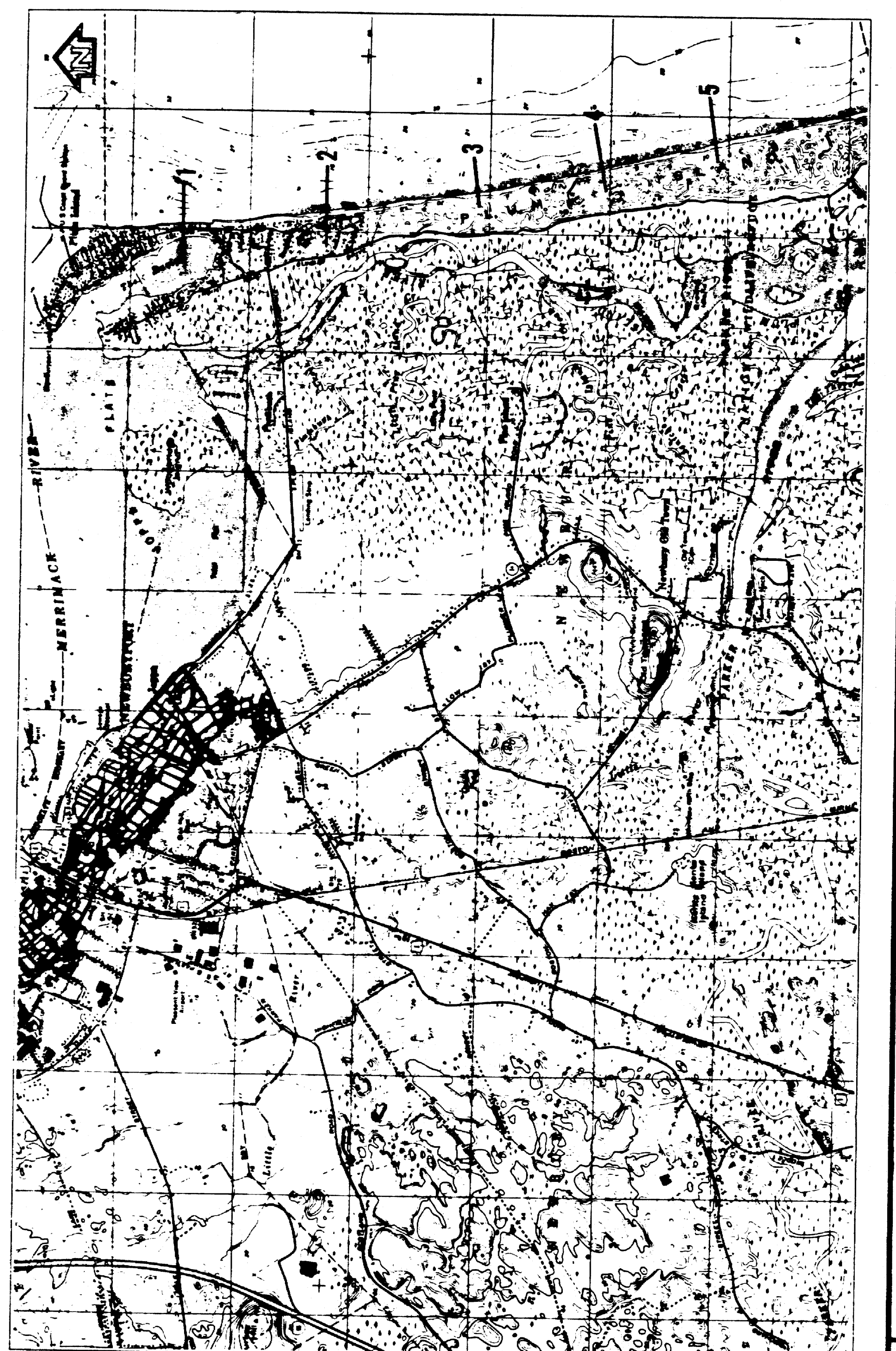
The methodology for analyzing wave runup was developed by Stone and Webster Engineering Corporation (Reference 15). The wave runup computer program operates using an ensemble of deepwater wave heights, H_i; the stillwater elevation, S_*; a wave period, T_s; and the beach slope, m. For Floodport, wave heights range from 2 feet to 6 feet; the wave period is 4 seconds.

These concepts and equations were used to compute wave envelope elevations associated with the 100-year storm surge. Accurate topographic, land-use, and land-cover data are required for the coastal analyses. Maps of the study area, prepared at a scale of 1:2,400, with contour interval of 5 feet, were used for the topographic data (Reference 16). The land-use and land-cover data were obtained by field surveys.

Wave height and wave runup were computed along transects that were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were located close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 2 illustrates the location of the transects for the community. A listing of the transect locations and stillwater elevations, as well as the maximum wave crest (or wave runup) elevations, is provided in Table 3.

Along each transect, wave envelope elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Between transects, elevations were interpolated using the previously cited topographic maps, land-use data, land-cover data, and engineering judgment to determine the areal extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergo any major changes. The results of this analysis are summarized in Table 4.

Historic flood damage information was also used in the determination of floodprone areas along the Floodport shoreline (Reference 19).



APPROXIMATE SCALE

6000 0 6000 12000 18000 FEET

TRANSECT LOCATION MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF FLOODPORT, MA

(FLOOD CO.)

FIGURE 2

Table 3. Transect Descriptions

Transect	Location	100-Year Flood Elevation (Feet) Stillwater	100-Year Flood Elevation (Feet) Maximum Wave[1]
1	From Plum Island Point south to Plum Island Turnpike, extended east	9.2 – 8.2	14[2]
2	From Plum Island Turnpike, extended east, to Perry Road, extended east	9.2	18[3]
3	From Perry Road, extended east, to Mason Street, extended east	9.3	14[2]
4	From Mason Street, extended east, to 8th Street, extended east	9.3	14[2]
5	From 8th Street extended east, to approximately 3,000 feet south of 1st Street	9.3	17[3]

[1]Due to Map Scale Limitations, Maximum Wave Elevation Not Shown on FIRM
[2]Maximum Wave Height Elevation
[3]Maximum Wave Runup Elevation

Table 4. Transect Data

Flooding Source	Stillwater Flood Elevation (Feet) 10-Year	50-Year	100-Year	500-Year	Base Flood Elevation (Feet)[1]
Atlantic Ocean and Merrimack River	8.2	8.9	9.2	9.8	9.14
Transect 1	5.9	7.2	8.2	8.9	8-11
Atlantic Ocean					
Transect 2	8.2	8.9	9.2	9.8	9.18
Transect 3	8.3	9.0	9.3	10.0	9-14
Transect 4	8.3	9.0	9.3	10.0	9-14
Transect 5	8.3	9.0	9.3	10.0	9-17

[1]Due to Map Scale Limitations, Base Flood Elevations Shown on the FIRM Represent Average Elevations for the Zones Depicted.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400, with a contour interval of 5 feet (Reference 16).

For tidal areas without wave action, the 100- and 500-year floodplain boundaries were delineated using topographic maps at a scale of 1:2,400, with a contour interval of 5 feet (Reference 16). For the tidal areas with wave action, the floodplain boundaries were delineated using the elevations determined at each transect; between transects, the boundaries were interpolated using engineering judgment; land-cover data; and topographic maps at a scale of 1:2,400, with a contour interval of 5 feet (Reference 16). The 100-year floodplain was divided into whole-foot elevation zones based on the average wave envelope elevation in that zone. Where the map scale did not permit these zones to be delineated at l-foot intervals, larger increments were used.

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, V, and VE); and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 100-year floodplain boundary is shown on the Flood Insurance Rate Map (Exhibit 2.)

Approximate 100-year floodplain boundaries in some portions of the study area were taken directly from the Flood Hazard Boundary Map (Reference 20).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the l00-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodway presented in this study was computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations have been tabulated for selected cross sections (Table 5). In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

Portions of the floodway for the Mill River extend beyond the corporate limits.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 3.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NGVD)			
CROSS SECTION	DISTANCE[2]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Mill River								
A	1,200	28/14	102	8.2	13.5	11.0[3]	11.0[3]	0.0
B	5,300	90/60	547	1.5	17.1	17.1	17.1	0.0
C	7,400	95/50	621	1.7	22.9	22.9	23.1	0.2
D	9,300	110/75	641	2.2	23.9	23.9	24.3	0.4
E	11,000	130/76	675	2.4	25.4	25.4	26.0	0.6

1Feet Above U.S. Route 1
2Width/Width Within Corporate Limits
3Elevation Computed Without Consideration of Backwater From Massachusetts Bay

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF FLOODPORT, MA

(FLOOD CO.)

FLOODWAY DATA

MILL RIVER

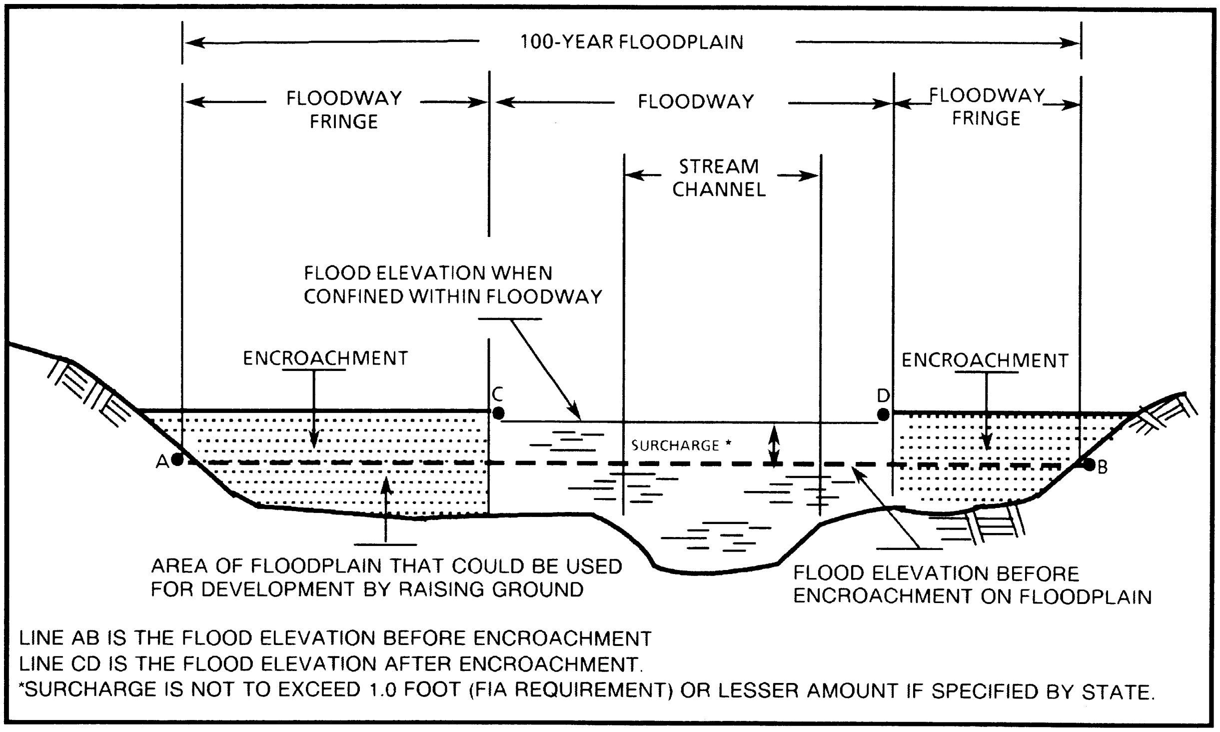


Figure 3. Floodway Schematic

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown at selected intervals within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

7.0 OTHER STUDIES

Using National Ocean Survey tide gage data, the COE has predicted 10-, 50-, 100-, and 500-year flood levels at Boston, Massachusetts, and Portsmouth, New Hampshire (Reference 21). The COE results compare favorably with flood levels determined in this study, considering the distance between Ipswich and the National Ocean Survey gaging stations.

Flood Insurance Studies for the Towns of West Newbury and Georgetown have been published (References 22 and 23). The results of this study are in exact agreement with the results of those studies.

A Flood Insurance Study for the Town of West Newburyport is in progress (Reference 24). The results of that study will be in exact agreement with the results of this study.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and technological Hazards Division, FEMA, J. W. McCormack Post Office and Courthouse Building, Room 462, Boston, Massachusetts 02109.

9.0 BIBLIOGRAPHY AND REFERENCES

1. Commonwealth of Massachusetts, Department of Commerce, Division of Census, Population-Area-Density, Boston, Massachusetts, 1980.

2. New England River Basins Commission, Report of the Southeastern New England Study, Boston, Massachusetts, December 1975.

3. Massachusetts Agricultural Experiment Station, Remote Sensing, 20 Years of Change in Essex County, Massachusetts, 1951-1971, William P. MacConnel, August 1974.

4. Commonwealth of Massachusetts, Department of Commerce, Profile of Floodport, Boston, Massachusetts, 1975.

5. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, United State Coast Pilot 1, Atlantic Coast, Eastport to Cape Cod, November 1976.

6. U.S. Department of the Army, Corps of Engineers, New England Division, National Shoreline Study, Regional Inventory Report, North Atlantic Region, Volume 1, Waltham, Massachusetts, 1971.

7. U.S. Department of the Interior, Geological Survey, Interagency Advisory Committee on Water Data, Office of Water Data Coordination, Hydrology Subcommittee, Bulletin No. 17B, Guidelines for Determining Flood Flow Frequency, September 1981, revised March 1982.

8. U.S. Department of the Interior, Geological Survey, Open-File Report, Computer Program E-431, Users Manual, Computer Applications for Step-Backwater and Floodway Analyses, James O. Shearman, 1976.

9. Stone and Webster Engineering Corporation, Development and Verification of a Synthetic Northeaster Model for Coastal Flood Analysis, Boston, Massachusetts, October 1978.

10. Stone and Webster Engineering Corporation, SWECO 7501-NP-A, Two-Dimensional Coastal Storm Surge Model, Boston, Massachusetts, July 1977.

11. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Environment Data Service, Synoptic Weather Charts, 1931, 1940, 1944, 1950, 1953, 1954, 1957, 1958, 1959, 1960, 1961, 1962, 1966, 1967, 1968, 1969, 1970, 1972, 1976, and 1978.

12. Tetra Tech, Inc., Coastal Flooding Handbook, prepared for the Federal Emergency Management Agency, Pasadena, California, May 1977.

13. Stone and Webster Engineering Corporation, Determination of Coastal Storm Tide Levels, Boston, Massachusetts, October 1978.

14. National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated with Storm Surges, Washington, D.C., 1977.

15. Stone and Webster Engineering Corporation, Manual for Wave Runup Analysis, Coastal Flood Insurance Studies, Boston, Massachusetts, November 1981.

16. James W. Sewall Company, Topographic Maps, Scale 1:2,400, Contour Interval 5 Feet: Floodport, Massachusetts (1977).

17. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, Davis, California, April 1984.

18. U.S. Department of the Army, Corps of Engineers, Galveston District, Guidelines for Identifying Coastal High Hazard Zones, Galveston, Texas, June 1975.

19. U.S. Department of the Interior, Geological Survey, Water Resources Investigations 78-61, Coastal Flood of February 7, 1978, in Maine, Massachusetts, and New Hampshire, 1979.

20. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, Town of Floodport, Massachusetts, Scale 1:6,000, April 4, 1978.

21. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Tide Table, 1931-1984, East Coast of North and South America, published annually.

22. Federal Emergency Management Agency, Flood Insurance Study, Town of West Newbury, Massachusetts, December 15, 1979.

23. Federal Emergency Management Agency, Flood Insurance Study, Town of Georgetown, Massachusetts, December 4, 1978.

24. Federal Emergency Management Agency, Flood Insurance Study, Town of Newburyport, Massachusetts, unpublished.

Executive Office of Environmental Affairs, Massachusetts Coastal Zone Management Plan, Massachusetts Coastal Regions and an Atlas of Resources, Chapter 5, June 1977.

Executive Office of Environmental Affairs, Massachusetts Coastal Zone Management Program and Final Environmental Impact Statement, 1978.

U.S. Department of the Army, Corps of Engineers, Coastal Engineering Research Center, Shore Protection Manual, Volume I, Fort Belvoir, Virginia, 1973.

U.S. Department of the Army, Corps of Engineers, New England Division A Report on the Assessment of Flood Damage Resulting from the Storm of February 6-7, 1978, Along the Coastline from Orleans, Massachusetts, to New Castle. New Hampshire, Waltham, Massachusetts, February 1979.

U.S. Department of the Army, Corps of Engineers, New England Division Tidal Flood Profiles. New England Coastline, Waltham, Massachusetts, 1979.

EXHIBIT 3 - ELEVATION REFERENCE MARKS

Reference Mark	FIRM Panel	Elevation (Feet NGVD)	Description of Location
RM1	0005	191.640	Disk, stamped "B 127 1942," set in concrete post at the intersection of Willamina-Sheridan Highway and Northwest Lincoln Street, 15 feet north of the north curb of the highway, 1 foot west of the curb of Lincoln Street. Established by U.S. Bureau of Reclamation.
RM2	0010	194.678	Disk, stamped "Y 156 1941," set in northeast corner of main span of Bridge Street bridge, on top of curb at east edge of roadway. Established by U.S. Bureau of Reclamation.

Appendix D

Converting to the North American Vertical Datum of 1988

D.1 Background

Historically, the most common vertical datum used for FEMA flood hazard studies/restudies and map revisions has been the National Geodetic Vertical Datum of 1929 (NGVD29). Subsequent to the establishment of the North American Vertical Datum of 1988 (NAVD88), new flood hazard studies are often referenced to that datum.

D.2 Data Collection

The goal of the NFIP is to convert all flood hazard studies/restudies and map revisions to NAVD88. The FMPCC will be responsible for applying proper vertical datum protocols for new and/or revised flood hazard data when preparing or revising flood hazard study/restudy materials that have been chosen for the datum conversion. FEMA recognizes that there are, and will continue to be, limiting factors in achieving this conversion. To evaluate the suitability of a subject jurisdiction for datum conversion, the FEMA RO, SC, or FMPCC should gather the following information during the initial coordination efforts for a study or restudy:

- Datum used for the existing study
- Number (percentage) of streams that will be revised and the number of unrevised flooding sources that must be converted to NAVD88 if the datum conversion option is chosen
- Conversion factor from NGVD29 to NAVD 88 for the subject community
- Confirmation of ability to apply a conversion factor for the subject community without creating statistically significant variances from the high to the low conversion values
- Range of conversions from NGVD29 to NAVD88 across the community
- Reference datum used by FEMA for adjacent communities
- Datum of choice for the local surveyors and any known difficulties that the community would have with the use of NAVD88

D.3 Conversion Criteria

Once the information specified in Subsection D.2 has been gathered, FEMA will make the final decision regarding the datum to which the new, revised, and unrevised flood hazard information will be referenced. When a new or revised study is being processed, the decision to use

NAVD88 over NGVD29 will depend largely on the data gathered early in the process. Criteria that facilitate a decision to convert from NGVD29 to NAVD88 are as follows:

- All flooding sources in the community are being studied or restudied.
- The conversion range from NGVD29 to NAVD88 for the community is within 0.2 foot.
- The SC is able to use NAVD88 for the study/restudy.
- The community is already using NAVD88.

D.4 Conversion of Unrevised Flood Elevations

When an SC submits restudy information referenced to NAVD88 but does not address the remainder of the unrevised flood elevations, the PO or his/her designee may direct the FMPCC to convert the flood hazard information for the entire community to NAVD88. The decision by the PO or his/her designee will be contingent on a case-by-case cost-benefit assessment performed by the FMPCC. If the PO or his/her designee determines the cost to convert the entire community is reasonable (considering the other scope of work), the FMPCC shall follow the procedures in Subsections D.4.1, D.4.2, and D.4.3 of this Appendix.

D.4.1 Single Conversion Factor

A single conversion factor from NGVD29 to NAVD88 may be applied when the conversion does not result in a statistically significant variance from the mean. When a single conversion factor is applied, the following should procedures should be applied:

- Use the SC information as is.
- Convert the ERM elevations using VERTCON.
- Convert static (primarily, lacustrine) flood elevations using VERTCON.
- Determine an average conversion factor for the subject community and apply the average to the nonstatic flood elevations. The average conversion may be obtained by developing an average from the conversions provided for each USGS topographic quadrangle map.
- Use the proposed Section 3.3 of the FIS report, which explains the datum conversion issues. Sample paragraphs are provided as Subsection D.6 of this Appendix.

D.4.2 Multiple Conversion Factors

In cases where the range of conversion factors across the subject community is prohibitively high (thereby resulting in statistically significant variances from the mean), the FMPCC shall not apply a standard conversion factor for the entire community. In the event that conversion to NAVD88 remains a desirable option, the FMPCC shall convert the unrevised flood hazard elevations on a stream-by-stream basis. In this case, the FMPCC shall develop an average conversion factor for each stream or flooding source by establishing three conversion factors at three locations and developing an average conversion factor from those data. The FMPCC shall then present the conversion in a table to be placed on the FIRM and in the FIS report. In addition, the FMPCC shall use the paragraphs presented in Subsection D.6.

D.4.3 Stream-by-Stream Conversion

In cases where the range of conversion factors for a given flooding source is prohibitively high (thereby resulting in statistically significant variances from the mean), the FMPCC shall remodel the subject stream by applying the VERTCON program to the effective model. (NOTE: To date, these details and protocols have not been finalized and FIS report paragraphs have not been formulated to address this situation.)

D.5 Conversion Back to NGVD29

In cases where the SC information is provided in NAVD88, but the PO or his/her designee determines that a full conversion is not an acceptable solution because of cost constraints, the FMPCC shall develop an average conversion factor and apply it to convert the flood elevations back to NGVD29. For static flood elevations, the FMPCC may apply VERTCON or a comparable datum conversion software package to convert the NAVD88 elevations to NGVD29. In cases where an average conversion factor is not practical, the FMPCC may apply the approaches outlined in Sections D.4.2 and D.4.3 as warranted.

D.6 Paragraphs for Study Report

For all studies and restudies processed by the FMPCC, the FMPCC shall insert the following paragraphs into the new or revised FIS report as Section 3.3, "Vertical Datum."

First Paragraph

> All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). Now that the North American Vertical Datum of 1988 (NAVD88) has been finalized, many FIS reports and FIRMs are now being created or revised using NAVD88 as the referenced vertical datum.

Second Paragraph

> All flood elevations shown in this FIS report and on the FIRM are referenced to [*FIS/FIRM datum*]. Structure and ground elevations in the community must, therefore, be referenced to [*same datum*]. It is important to note that adjacent communities may be referenced to [*other datum*]. This may result in differences in base flood elevations across the corporate limits between the communities.

Variable Paragraph

Prior versions of the FIS report and FIRM were referenced to NGVD29. When a datum conversion is effected for an FIS report and FIRM, the Flood Profiles, base flood elevations (BFEs) and Elevation Reference Marks reflect the new datum values. To compare structure and ground elevations to BFEs shown in the FIS report and on the FIRM, the structure and ground elevations must be referenced to the new datum values.

Third Paragraph

As noted above, the elevations shown in the FIS report and on the FIRM for [community name] are referenced to [FIS/FIRM datum]. Ground, structure, and flood elevations may be compared and/or referenced to [other datum] by applying a standard conversion factor. [Add sentences ... see instructions below].

One of the following three groups of sentences shall be used at this point in the third paragraph:

- The conversion factor to [other datum] is [conversion factor]. The Elevation Reference Marks are referenced to NGVD29 as well as NAVD88 as indicated in the Elevation Reference Marks table shown on the FIRM.
- The conversion from NGVD29 to NAVD88 ranged between ___ and ___ for this community. An average conversion factor could not be established for the entire community due to this large range in conversions. The elevations shown in the FIS report and on the FIRM were, therefore, converted to NAVD88 using a stream-by-stream approach. In this method, an average conversion was established for each flooding source and applied accordingly. The conversion factor for each flooding source in the community may be found in the following table as well as on the FIRM. Elevation Reference Marks are referenced to NGVD29 as well as NAVD88 as indicated in the Elevation Reference Marks table shown on the FIRM.
- Elevation Reference Marks are referenced to NGVD29 as well as NAVD88 as indicated in the Elevation Reference Marks table shown on the FIRM. For comprehensive conversion factors to [other datum], contact the National Geodetic Survey at the address referenced below.

The final sentences of the third paragraph will be as follows.

- The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, the datum conversion should be applied to the BFEs shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

Fourth Paragraph

For more information on NAVD of 1988, see *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988*, FEMA Publication FIA-20/June 1992, or contact the Vertical Network Branch, National Geodetic Survey, Coast and Geodetic Survey, National Oceanic and Atmospheric Administration, Rockville, MD (Internet address http://www.ngs.noaa.gov.)

Appendix E

Technical Support Data Notebook

This appendix describes the responsibilities of the FMPCC with regard to FEMA's requirement that SCs organize and submit all technical and administrative support data in a Technical Support Data Notebook (TSDN). The TSDN, which contains all of the support data developed by the SC, was created because of the increasing need to refer to support data for studies, restudies, and map revisions.

E.1 Background

In May 1989, FEMA issued the first *Guide for Preparing Technical Support Data Notebook*, latest version dated January 1990 (Reference 19), as an attachment to the SOW for SCs. The Guide, which applies to studies and restudies procured since October 1, 1989, sets forth procedures for the development of the TSDN and requires that the TSDN be submitted to the FMPCC along with the draft study or restudy deliverables.

The following subsections outline the FMPCC requirements for processing and managing technical support data for studies and restudies, as well as for map revision data generated by revision requesters and the FMPCC. Subsections E.2 and E.3 describe how the FMPCC is to organize and maintain SC-generated and FMPCC-generated data during processing of the study or restudy using the TSDN format.

In instances where guidance is not provided by these Guidelines, the FMPCC shall resolve issues through consultation with the PO.

E.2 Study Contractor-Generated Support Data

For studies and restudies, SCs shall organize all deliverable items into a TSDN and submit the TSDN to the FMPCC in a reproducible format. The hydrologic and hydraulic analyses (H&H) must be delivered in an electronic format. Items to be submitted in the TSDN include the original study products (e.g., draft FIS report, profiles, tables), work maps, and associated technical support data (e.g., H&H, survey data, general correspondence, and other documentation).

The TSDN is divided into five major sections, each encompassing a separate category of information typically generated by the SC during the preparation of a study or restudy. These major sections provide separate categories under which the SC is to file general documentation (e.g., Special Problems Reports (SPRs), telephone conversation records, meeting minutes/reports, and general correspondence), engineering analyses, draft FIS report, mapping information, and miscellaneous reference materials. Materials that cannot be physically included in the TSDN because of size or volume are to be bound and clearly labeled and identified as exhibits to the TSDN.

An SC will prepare a transmittal letter to accompany the TSDN that provides an inventory of all materials being shipped to the FMPCC. The SC shall retain copies of pertinent data for use in responding to appeals as well as concerns and issues that may develop during FMPCC processing of the study/restudy.

After receiving the draft study/restudy submittal and TSDN from the SC, the FMPCC shall perform a cursory review of the TSDN to ensure that all sections are complete and that all data are labeled in a neat, clear, and organized manner in accordance with the instructions outlined in Reference 19. The SC submittal should include an index form for each section of the TSDN. If any information is missing or unlabeled, the FMPCC shall contact the SC for clarification. If the FMPCC determines during its review that the TSDN does not conform to the guidelines for the preparation of the TSDN, the FMPCC shall consult with FEMA to determine if the FMPCC shall revise the TSDN submittal or return it to the SC for revision. If the TSDN is returned to the SC, the FMPCC shall contact the RO to discuss their concerns with the SC submittal.

When data are common to more than one community, the TSDN for each community is to contain a complete copy of the shared data, or the location of the data is to be cross-referenced to a form for each section and subsection of the TSDN. To maintain the integrity of the original TSDN submittal, the FMPCC shall make copies of any data that the FMPCC may need to use as markup copies. The original data in the TSDN are to be retained for eventual digital storage.

E.2.1 General Documentation

The General Documentation section provides a comprehensive chronology of all SPRs, telephone conversation reports, meeting minutes/reports, and general correspondence developed by the SC during the processing and preparation of the study/restudy.

An SPR includes any special problems/issues the SC encountered. It must include written documentation generated or received by the SC that pertains to specific problem identification and/or special processing requirements. An SPR index sheet is to be provided that includes the SPR date, title, and exhibit number.

Telephone conversation records are to include all written records or oral communication documented by the SC. The index sheet is to contain the memorandum date and government firm/private agency contacted.

Meeting minutes/reports include the written summaries of discussions in meetings between the SC and other parties, including all agencies and firms. They typically include minutes of standard meetings such as T&C, final CCO, and initial CCO meetings.

General correspondence is the written correspondence generated or received by the SC and may include letters; transmittals; memorandums; general status reports and queries; and internal communications, routing slips, and notes.

E.2.2 Engineering Analyses

The FMPCC shall perform a cursory review of the H&H to ensure they meet following specifications: the information is arranged in alphabetical order according to the flooding source/stream name; it is properly labeled to identify the SC, name of community, and State; and it includes type of model used, date of analysis, and exhibit number(s) assigned to those analyses that cannot be physically included in the TSDN because of size or volume. The information is to be neatly recorded in pen or dark pencil on the index sheet and annotated to indicate whether the product is one of several others and whether it pertains only to the appropriate community study/restudy. It is to be complete and of original quality and include any other relevant data to assist in identifying the study.

The FMPCC shall verify that both paper copies and/or copies of computer models on diskette are maintained with the TSDN. Paper copies of the hydrologic or hydraulic computer models used or generated for the study/restudy are to be individually bound and labeled according to the community and flooding source to which they apply, properly identified by exhibit number, and listed on the index sheet. Copies of computer models on diskette shall be packaged in computer envelopes or binders, labeled properly, identified by exhibit number, and listed on the index sheet. The FMPCC shall store the diskettes to ensure their integrity and that they are readily accessible for retrieval and use in responding to both internal and external information requests.

Photographic or mapping information that may have been used in the development of the models is not to be included in this section. Such information shall be included in the "Mapping Information" section discussed in E.2.5.

E.2.3 Key to Cross-Section Labeling and Key to Transect Labeling

The FMPCC shall perform a cursory review to ensure that the Key to Cross-Section Labeling and Key to Transect Labeling include comprehensive cross referencing among the field survey notes, draft study/restudy materials, hydraulic computer analysis, and, if readily available, U.S. Environmental Protection Agency (EPA) Reach File Numbers. These sections will identify the cross-section and transect information developed by the SC and the FMPCC for each flooding source. The FMPCC shall verify that the SC portions of the Key to Cross-Section Labeling and Key to Transect Labeling are complete.

Specifically, the FMPCC shall ensure that the information pertains to only one flooding source and is arranged from the mouth or point farthest downstream to the point farthest upstream.

E.2.4 Draft Flood Insurance Study Report

The FMPCC shall ensure that the draft FIS report section contains all relevant study/restudy components the SC prepared for submission to FEMA for the FMPCC's technical review, processing, and publication of the study/restudy. The data that must be included are the draft text, flood profiles, floodway data tables, summary of elevation tables, transect location tables (if applicable), surge elevation tables (if applicable), the certification statement of work accomplished and any other relevant support data. The FMPCC shall provide the SC with a Summary of Map Actions from the CIS database and LOMCs to be submitted with the TSDN.

The FMPCC shall verify that the information in this section includes only the most up-to-date record copies of the draft study/restudy report. The FMPCC shall ensure that the draft pertains only to the appropriate community study/restudy. It must be legible; properly labeled; easily identified by community; complete; and of original, reproducible quality.

E.2.5 Mapping Information

The FMPCC shall ensure that the "Mapping Information" section includes comprehensive mapping data relating to the processing of the study/restudy. This section identifies the various types of mapping the SC used to map the floodplain and/or floodway for each flooding source. It should also include the Digital Data Submission Checklist if SC work maps or digital base map information is submitted. This data should be submitted on diskette or CD. The FMPCC shall verify that the information is properly labeled with the correct SC and community name and that it is easily identified by flooding source and community. This information must include the type of map, the date of the map, the number of map sheets, and the exhibit numbers assigned to those maps that cannot be included in the TSDN because of size limitations. All supplemental materials, such as topographic maps and aerial photographs, shall be listed with a concise explanation of how the final work maps were delineated. Mapping information shall be included within the notebook or bound and labeled separately and identified by exhibit number.

E.2.6 Miscellaneous Reference Materials

All other support data relating to the processing of the study/restudy not previously covered by the preceding sections shall be included in the "Miscellaneous Reference Materials" section. An inventory of all essential and nonessential data shall be compiled. Support data, in the form of reference materials (e.g., field survey notes and notebook, watershed studies, site visit photographs, community population and demographic studies, tax base reports, legal references) and other relevant materials shall be included in this section.

The FMPCC shall verify that miscellaneous reference materials are properly labeled and exhibit number(s) are assigned to those materials that cannot be included in the TSDN because of size or volume.

E.3 FMPCC-Generated Support Data

There are two instances in which the FMPCC physically enters information into the TSDN prepared by the SC. The FMPCC is required to fill out the FMPCC portion of the Key to Cross-Section Labeling or Key to Transect Labeling Index sheets contained in the TSDN. In addition, as the FMPCC processes the study/restudy, it may be necessary to make revisions to the SC data submittal included in the TSDN to correct discrepancies or errors in original SC data.

Data in error shall be marked “VOID,” removed from the TSDN, replaced by the revised data, and then stored by the FMPCC until the study/restudy processing has been completed. At that time, the voided data shall be discarded.

When adding revised material to the TSDN, the FMPCC shall properly label and place the materials in the correct section in accordance with the procedures outlined in Reference 19.

Essential data may typically include, but are not limited to, hydraulic analyses prepared by the FMPCC and concurrence or directives from FEMA HQ and ROs, or data prepared by the SC, such as telephone conversation records or meeting minutes, relating to changes or modifications to the study/restudy.

Appendix F

Procedures for Storing Map Revision Data

F.1 Requester-Generated Support Data

As an integral part of the overall process for supporting map revisions, the FMPCC reviews technical, scientific, and other administrative support data prepared and submitted by a revision requester. The review typically consists of, but is not limited to, ensuring that all support data received are complete, technically adequate, in compliance with FEMA-specified rules and regulations, and sufficient to support a given map revision request. Most technical support data generated by the requester are subject to the same engineering and mapping standards outlined in these Guidelines.

Upon initial receipt of support data from the requester, the FMPCC shall conduct a cursory evaluation of the completeness and reproducible quality of the support data. Examples of the types of support data that requesters may submit are listed below.

- Correspondence from the requester, the community, and, where applicable, the State, or other interested parties
- technical support data such as calculations, graphs, charts, technical reports, floppy disks, and computer printouts containing both input and detailed output for hydrologic and/or hydraulic analyses
- Project location, topographic, survey, and tax mapping information; aerial photographs; and design drawings
- Annotated copies of effective NFIP maps, Flood Profiles, Floodway Data Tables, and Transect Location Tables

In most cases, the support data submitted by the requester shall follow the same organizational and reproducible quality standards issued for studies and restudies. Specifically, whenever possible, the FMPCC shall provide guidance to the requester (by issuing written directions or through telephone conversations) regarding proper labeling and data identification requirements, as well as requirements concerning the legibility of materials that must be reproduced.

To the extent possible, the FMPCC shall review requester-generated support data for compliance with FEMA requirements for the identification, labeling, completeness, and quality of the data.

F.2 FMPCC-Generated Support Data

When processing map revision cases, the FMPCC generally develops supporting information during the review and evaluation of the revision request. Most of the FMPCC-generated data typically consists of internal review information and correspondence with the requester, State agencies, FEMA, community officials, or other agencies. The remaining information generated by the FMPCC pertains to the appeal period and/or related statutory requirements for the establishment or modification of BFEs, as applicable.

For purposes of these Guidelines, FEMA identified two separate phases of FMPCC processing, wherein uniform guidelines and specifications are necessary for revisions: Review Processing Phase and Post-Review Processing Phase. The Review Processing Phase includes FMPCC activities associated with the initial identification, coordination, and technical review of a map revision case up to the resolution of that case. The Post-Review Processing Phase relates to those activities performed by the FMPCC after the case has been resolved to close out the file and prepare the supporting information for active storage and eventual processing by the ESDPF staff.

F.2.1 Review Processing Phase

The FMPCC, to the extent possible, shall provide initial guidance to the requester for the preparation and submittal of his or her technical support data for a revision. Therefore, if there is contact with the requester prior to data submittal, the FMPCC shall provide overall guidance concerning the submittal quality of the support data to facilitate eventual digital conversion of the data for permanent retention. The requester is required to submit only the essential or relevant data that fully support the FEMA requirements for proper evaluation of the map revision request. Once support data are received, the FMPCC reviews the revision request and develops revision case files under the procedures outlined in this section.

Generally, the support data submitted by the requester and the FMPCC-generated data shall contain what will be defined as essential and nonessential data. These terms, respectively, are used to differentiate between support data critical to understanding or recreating conditions that resulted in a map revision or other resolution of the map revision request, which therefore must be maintained by FEMA, and data generated as part of the internal production process or for general, informational purposes only. Nonessential data are usually needed for temporary storage only (i.e., throughout the review and production process) and can be discarded once the case has been resolved or during the Post-Review Processing Phase.

The FMPCC shall use judgment in determining what data are considered essential or nonessential. Because of the nature of map revision cases, it is not possible to provide specific guidance concerning the essential versus nonessential character of individual pieces of supporting information. The examples given in the following paragraphs are for typical revision cases and shall not be construed as inflexible. However, the FMPCC shall also refrain from retaining materials that are clearly not critical to understanding or recreating conditions that pertain to the resolution of a map revision case.

Examples of essential revision support materials include:

- All official correspondence, including resolution letters (e.g., LOMRs, denial letters)
- FEDD file materials
- Hydrologic and hydraulic models, calculations or computer printouts
- Summary tables

- Technical reports
- Topographic maps, tax maps, survey plats, and aerial photographs (all sizes and formats)

Except for the FEDD file information, the FMPCC shall separate materials that are larger than 11″ × 17″ and shall physically maintain those materials outside the revision case file. Essential data that are 11″ × 17″ or smaller shall be filed as part of the FMPCC revision case file, unless the data in question are in the form of a voluminous report. The FMPCC shall prepare a cross-referenced listing of the essential data not included in the revision case file so that they can be readily identified as part of the revision package. This listing shall be maintained within the FMPCC revision case file. The contents of the FMPCC revision case file should:

- Have a maximum size of 11″ × 17″;
- Be of legible quality (printed, typed or handwritten in dark ink or pencil);
- Properly identify the community name, requester name, and the date when data were prepared (using ink or dark pencil);
- Be in good whole condition without tears or missing segments; and
- Be of original copy quality for future digital conversion.

The nonessential materials generally consist of large blueline prints of mapping information (Preliminary or Revised Preliminary copies of FIRMs and FBFMs), duplicate data, extraneous reports or unrelated support data, void or superseded data, internal memorandums, transmittals, and other internal processing information. Although these types of data must be maintained throughout the Review Processing Phase of a revision, they are not critical in recreating the results for the final revision determination and, therefore, would not be considered for digital conversion by FEMA at a future date.

F.2.1.1 Standard-Size Revision Case File Items

For purposes of these Guidelines, the standard-size FMPCC revision case file refers to any file that consists of a legal- or letter-sized manila folder containing original general correspondence, mapping information, technical information, or data (excluding computer printouts for hydrologic and hydraulic models, and information generated as part of the FEDD file) that are equal to or smaller than 11″ × 17″. The FMPCC shall file all documents, reports, mapping information, or other support data (including hydrologic and hydraulic computer printouts) larger than 11″ × 17″ separately, and shall include a listing of those oversized in the standard-size case file. The FMPCC shall maintain the FEDD file, as applicable, as a separate entity. Like the case file, the materials in the FEDD file should be complete, concise (to the extent possible), and in reverse chronological order.

F.2.1.1.1 Essential Case File Items

Essential items shall constitute the scannable portion of the case file and shall be organized in reverse chronological order. Data pertaining to specific technical areas shall, if practical, be grouped together in the case file, by reverse chronological order whenever possible. The FMPCC shall file the case file items deemed essential for future scanning on the right-hand side of the revision case file folder (i.e., the side with the filing label), using a two-pronged, Acco-style binder and retainer (or equivalent) at the top.

To facilitate proper identification of the data, the FMPCC shall include the following information on the front or the inside cover of the revision case file:

- Community identification number;
- Community name, type (CTY,V,TWP,CO), and State;
- Requester's first initial and last name;
- Flooding sources;
- Affected map type (FHBM, FIRM, or FBFM) and map panel number;
- Case resolution date (MM/DD/YY); and
- FMPCC identification number.

In addition to the labeling on the file noted above, the FMPCC shall place a summary listing of the essential materials pertinent to the revision case not physically included within the revision case file. The information on this listing shall include the title, date, map scale (if applicable), and a description of the contents of each essential item. The FMPCC case identification number shall be included at the top center of that page.

Because of the critical nature of the data contained in computer printouts, a second or separate listing of computer printouts supporting the revision case shall be placed behind the summary of essential materials not physically included in the revision case file. Generally, because of their size, computer printouts are filed separately from the revision case file, but they are a part of the essential items requirement. Again, this listing shall identify the various computer model runs (e.g., study/restudy conditions, existing conditions, proposed conditions), the dates of the runs, and the names of the flooding sources modeled for each run.

F.2.1.1.2 Nonessential Revision Case File Items

The FMPCC shall maintain nonessential standard-size items in the revision case file. The FMPCC shall place nonessential items relevant to the FMPCC processing of the revision request, but not pertinent to the technical support data, on the left-hand side of the revision case file folder. The FMPCC shall attach these to the top of the file folder using a two-pronged, Acco-style binder and retainer (or equivalent). The FMPCC label the data as nonessential. The header sheet the FMPCC shall use is a standard 8-1/2″ × 11″ form, which reads "FMPCC INTERNAL PROCESSING FORMS; DO NOT SCAN." FEMA intends to delete from any permanent or new record, such as indefinite hard-copy storage or digital record, the data that the FMPCC considers to be nonessential to the resolution of a specific revision request.

F.2.1.2 Oversized Revision Case File Items

Oversized items also shall consist of essential and nonessential information. The FMPCC shall follow similar guidelines as before for maintaining only those data deemed necessary or critical for recreating and supporting the results of the resolution of a given revision request. Examples of essential oversized items are computer printouts, CD-ROMs or diskettes, survey or plat maps, construction drawings, topographic or aerial photographic maps, supplementary (bound) reports, transect maps, and tax maps.

The FMPCC shall file such data in boxes or shelving appropriate for storing oversized documents. To facilitate future retrieval, the FMPCC shall clearly label each oversized item with the appropriate community name, state name, requester name, and case number. The FMPCC also shall develop a listing of the essential oversized items that shall be included in the standard size case file for cross-referencing. Generally, the essential oversized items will not be scanned by ESDPF staff (except for the hydrologic or hydraulic computer models/printouts); therefore, the FMPCC will maintained them in hardcopy storage. The FMPCC shall archive essential computer models in their native format.

The FMPCC shall maintain nonessential oversized items only until such time as the revision case has been resolved. The FMPCC may then discard these items.

F.2.2 Post-Review Processing Phase

The FMPCC shall store all of the essential revision case files and FEDD files as noted earlier in this appendix for an indefinite period of time. FEMA intends to initiate the digital conversion of the revision case files and FEDD files, as applicable, by the ESDPF staff. This initiative shall be limited to those revisions case files and FEDD files prepared in accordance with the instructions given in these Guidelines.

Once FEMA initiates the digital conversion of revision files, a given revision file shall not be called in for digital conversion until approximately 1 year after its resolution date. The delay in call-in time is to allow the FMPCC to respond to inquiries pertaining to the revision case. It is anticipated that a large majority of these inquiries would be received within 1 year after case resolution. Therefore, the risk of having the responding FMPCC receive an inquiry while the revision case file is being converted to digital format will be minimized.

The FMPCC has organized the revision case file, the FEDD file, and the oversized items into the proper standard size format during the Review Processing Phase. Therefore, the effort required for the FMPCC at the time of call-in shall involve only retrieving the essential standard size case file and the FEDD file and transmitting them to the ESDPF. The FMPCC shall not transmit oversized items (except for the hydrologic and hydraulic computer printouts) to the ESDPF because these materials will not be digitally converted, and the summary listing will be a part of the digital file.

As is done with the digital study and restudy support data files, the ESDPF staff shall return the revisions case file to the FMPCC on CD-ROM for future use in responding to data requests from all sources. The CD-ROM record will be supplemented by the oversized items retained by the FMPCC in permanent hardcopy storage.

Appendix G

Coastal Flooding Methodologies

G.1 General Methodology

A variety of analytical methodologies may be used to establish BFEs and floodplains throughout coastal areas of the United States. These methodologies are too voluminous to be included in these Guidelines. This appendix itemizes references for the methodologies currently in use by FEMA for specific coastal flood hazards.

G.2 References

The publications below were prepared for, and are available from, FEMA, or they are currently used to prepare a coastal flood hazard assessment and establish BFEs. The publications prepared for FEMA will be provided to SCs or the FMPCC. The FMPCC should obtain copies of the other published data used to prepare coastal flood hazard assessment and establish BFEs, and be familiar with the use and application of the information presented in the publications referenced below.

Northeaster Flooding

Stone & Webster Engineering Corporation, "Development and Verification of a Synthetic Northeaster Model for Coastal Flood Analysis," 1978.

U.S. Department of the Army, Corps of Engineers, New England Division, Hydraulics and Water Quality Section, "Tidal Flood Profiles, New England Coastline," September 1988.

Hurricane Flooding

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, *Hurricane Climatology for the Atlantic and Gulf Coasts of the United States (NWS 38)*, April 1987.

Federal Emergency Management Agency, *FEMA Coastal Flooding Storm Surge Model*, Volumes 1, 2, and 3, August 1988.

Pacific Northwest Storm Flooding

CH2M HILL, Inc., "Determination of Flood Levels on the Pacific Northwest Coast for Federal Insurance Studies," *Journal of Hydraulics Division, ASCE*, D. E. Dorratcague, J. H. Humphrey, and R. D. Black, 1977, Vol. 103, 73–81.

U.S. Department of the Army, Corps of Engineers, Pacific Ocean Division, *Manual for Determining Tsunami Runup on Coastal Area of Hawaii*, August 1978.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report H-80-16, *Tsunami-Wave Elevation Predictions for American Samoa*, September 1980.

Tsunami Flooding

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report H-77-16, *Tsunami-Wave Elevations, Frequency of Occurrence for the Hawaiian Islands*, August 1977.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report CERC-87-7, *Tsunami Predictions for the Coast of Alaska, Kodiak Island to Ketchikan*, April 1987.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report H-80-16, *Tsunami-Wave Elevation Predictions for American Samoa*, September 1980.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report HL-80-18, *Type 19 Flood Insurance Study: Tsunami Predictions for Southern California*, 1980.

U.S. Department of the Army, Corps of Engineers, Pacific Ocean Division, *Manual for Determining Tsunami Runup on Coastal Area of Hawaii*, August 1978.

Great Lakes Mapping of Coastal Flooding Areas

U.S. Department of the Army, Corps of Engineers, *Revised Report on Great Lakes Open-Coast Flood Levels, Phases I and II*, April 1988.

U.S. Department of the Army, Corps of Engineers, *Great Lakes Wave Runup Methodology Study*, June 1989.

Federal Emergency Management Agency, *Guidelines for Great Lakes Wave Runup Computation and Mapping*, June 1991.

Dewberry & Davis, *Basic Analyses of Wave Action and Erosion With Extreme Floods on Great Lakes Shores*, Draft Report, October 1995.

Federal Emergency Management Agency, *Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping – Great Lakes,* Draft Report, August 1996.

Mississippi River Delta Flooding

Joseph N. Suhayda, *Attenuation of Storm Waves Over Muddy Bottom Sediments*, August 1984.

Wave Height and Runup Analyses

National Academy of Sciences, *Methodology for Calculating Wave Action Effects Associated with Storm Surges,* 1977.

Federal Emergency Management Agency, *Assessment of Current Procedures Used for the Identification of Coastal High Hazard Areas (V Zones),* September 1986.

Federal Emergency Management Agency, *Basis of Assessment Procedures for Dune Erosion in Coastal Flood Insurance Studies*, January 1989.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Coastal Engineering Research Center, WIS Report 19, *Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956-1975,* April 1989.

Federal Emergency Management Agency, *Wave Height Analysis for Flood Insurance Studies (Technical Documentation for WHAFIS Program Version 3.0)*, September 1988; Amended with Software, July 1989.

Federal Emergency Management Agency, *Wave Runup Model Version 2.0 (RUNUP 2.0)*.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, *Automated Coastal Engineering System*, Version 1.07, September 1992.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Coastal Engineering Research Center, WIS Report 20, *Southern California Hindcast Wave Information*, December 1992.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Coastal Engineering Research Center, WIS Report 30, *Hindcast Wave Information for the U.S. Atlantic Coast*, March 1993.

Evaluation of Coastal Structures

U.S. Department of the Army, Corps of Engineers, *Shore Protection Manual, Volumes I, II, and III*, 1984.

U.S. Department of the Army, Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, April 1985.

U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report CERC-89-15, *Criteria for Evaluating Coastal Flood Protection Structures*, December 1989.

Atlantic and Gulf Mapping of Coastal Areas

Federal Emergency Management Agency, *Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping*, Final Draft, March 1995.

Appendix H

Review and Analysis Requirements for Studies of Alluvial Fan Flooding Sources

H.1 General Guidance

As indicated in Appendix 5 of FEMA 37, *Flood Insurance Study Guidelines and Specifications for Study Contractors* (Reference 1), FEMA contractors and others may perform alluvial fan flooding analyses in three basic steps as described in the FAN computer program User's Manual (Reference 20). The three steps are as follows:

1. Determine the flood-frequency curve at the apex of the fan.
2. Determine the boundaries of the areas subject to flooding from the apex and the probabilities that points within that area will be flooded by a given discharge.
3. Calculate the base flood discharge.

Because the accuracy of the results of Step 3 above depends on the accuracy of the results of Steps 1 and 2 above, SCs are required to submit interim data for alluvial fan flooding analyses to FEMA and the FMPCC.

In addition to the methodology presented in Reference 1, the NRC has provided recommendations to FEMA regarding an approach for alluvial fan flood hazard mapping (Reference 25). At the request of the PO or his/her designee, the FMPCC shall use the approach recommended by the NRC.

Regardless of the analysis approach recommended by the FMPCC and approved by the PO or his/her designee, the FMPCC shall coordinate the analysis closely with the PO or his/her designee, FEMA RO staff, the SC (if appropriate), the revision requester (if appropriate), and appropriate community officials.

H.2 Interim Reviews of Study Contractor Submissions

The FMPCC shall adhere to the following procedures in reviewing the interim submission of SC data:

1. The FMPCC shall acknowledge receipt of the interim submittal. This will be done by telephone <u>and</u> by facsimile or e-mail transmission to the SC (if the request came directly from an SC), the Regional Engineer overseeing the study/restudy in the RO, and the appropriate Project Engineer at FEMA HQ within 5 days of receipt of the SC data.
2. The FMPCC shall review the submittal in accordance with the previously cited references or other appropriate methodology as determined through consultation with the PO or his/her designee, the Regional Engineer overseeing the study/restudy in the RO, and the SC.

3. Based on that review, the FMPCC shall prepare written comments, and prepare a draft memorandum for FEMA signature within 20 working days of receipt of the SC data.
4. The FMPCC shall deliver the memorandum to FEMA no later than 25 working days after receipt of the SC data.
5. The FMPCC shall distribute signed copies of the memorandum to the addressee of the memorandum, the Regional Engineer overseeing the study/restudy in the RO (if not the addressee of the memorandum), and the PO or his/her designee on the same day the memorandum is mailed.

If any problems arise during the review of the SC data, causing delays in processing, the FMPCC must coordinate with the PO or his/her designee, RPO, and SC as appropriate to ensure they are aware of the problems and the amended response timeframe.

Appendix I

Requirements for Ice-Jam Flooding Analyses

I.1 Introduction

An ice jam may be defined as an accumulation of ice in a river, stream, or other flooding source that reduces the cross-sectional area available to carry the flow and increases the WSEL. Ice usually accumulates at a natural or manmade obstruction or a relatively sudden change in channel slope, alignment, or cross-section shape or depth. In the northern United States, where rivers can develop relatively thick ice covers during the winter, ice jams can contribute significantly to flood hazards.

Ice jams typically occur in the same locations. In areas likely to be selected for a detailed FIS, historical documentation usually will indicate if ice-jam-caused flooding is a significant factor warranting consideration. In regions of the United States where ice jams are typical, FEMA directs the SC to investigate historical floods for evidence of ice-jam contribution as part of the study reconnaissance effort. Where ice jams have historically contributed to flooding in a community, the SC is requested to evaluate them in accordance with Appendix 3 of *Flood Insurance Study Guidelines and Specifications for Study Contractors* (Reference 1).

I.2 Types of Ice Jams

Ice jams have been classified in numerous ways by various investigators. In the U.S. Army Cold Regions Research and Engineering Laboratory Technical Note entitled "Methodology for Ice Jam Analysis" (Reference 22), ice jams were classified as freezeup or breakup types, moving or stationary types, and floating or grounded types. Each type is discussed in more detail below.

- Freezeup-type jams are associated with the formation and accumulation of frazil ice, which eventually forms a continuous ice cover. The SC usually does not need to address freezeup-type jams in an FIS because they are not associated with large discharge events. However, the SC should be aware of possible exceptions.
- Breakup-type jams are frequently associated with rapid rises in river stage, resulting from rainfall and/or snowmelt, and usually occur in the late winter or early spring. Because of the large volumes of ice that may be involved and the greater discharges associated with them, breakup-type jams are predominant in ice-jam-caused flooding and are typically the type requiring investigation in an FIS.
- Moving ice does increase water levels; however, these effects are minor compared to other types of jams and usually do not need to be considered in an FIS.
- Floating-type ice jams are considered to be those where the ice is not grounded to the channel bottom and significant flow takes place beneath the ice cover. Floating-type jams are typical of

deeper rivers. These ice jams can cause significant backwater effects and should be addressed in an FIS.

- Grounded-type jams are characterized by an ice cover that is partially grounded to the bed of the channel, with most of the flow being diverted into the overbank and floodplain areas. Grounded-type jams are typical of shallow, confined stream sections. These ice jams also can cause significant backwater effects and should be addressed in an FIS.

Additional information on the characteristics of ice jams is provided by the National Research Council of Canada in Chapter 10 of *Hydrology of Floods in Canada—A Guide to Planning and Design* (Reference 23).

I.3 Reconnaissance

When the SC determines ice jamming has historically resulted in flooding within the community under study, the SC should intensify the reconnaissance effort to acquire as much data as possible concerning ice-jam events in the community, on the streams being studied, and in the region. Such data should include, but not be limited to locations of ice jams, dimensions, ice volumes, causes, associated river stages and discharges, frequency of occurrence, lateral and upstream extent of flooding, season of occurrence, and other contributing or correlative factors. The SC also should investigate the nature of ice jamming common to the site (i.e., whether freezeup- or breakup-type jams are typical and whether grounded- or floating-type jams are typical).

Because very limited documented data are usually available, the SC should investigate all possible sources of information, including photographs, local residents, newspapers, community officials, and State and Federal agencies. During field reconnaissance, the SC also should investigate physical evidence of ice jams, such as high-water marks, damage to structures, or scars on trees, that may provide useful data for the analysis.

I.4 Analyses

Different methods may be used for establishing flood elevations in areas subject to ice-jam flooding, depending on the availability of data and the nature of the ice-jamming phenomena that occur at the site of interest. The methods outlined herein are applicable primarily to stationary-type ice jams that occur during periods of ice breakup. These types of jams historically have resulted in major flooding in certain regions of the United States. When conditions warrant alternate analytical methods, the SC will seek approval of alternate methods from the RO before proceeding. If documentation on the alternate method is unavailable or unclear, the FMPCC shall coordinate with the PO or his/her designee, RO staff, and SC to determine whether alternate methods were used.

The approaches in Subsections I.4.1 and I.4.2 are based on the development of stage-frequency relationships for two different populations (ice-jam flood stages and free-flow flood stages), which are then combined into a single composite frequency curve for flood stages at a site under study. Depending on the availability of ice-jam stage information, ice-jam stage-frequency relationships may be determined directly or indirectly as discussed in Subsections I.4.1 and I.4.2. The direct method is preferred where sufficient data are available.

I.4.1 Direct Approach

In sufficient data exist at the site of interest, the SC should establish an ice-jam stage-frequency distribution directly by analyzing the historical ice-stage data. This approach is preferred where ice-jam stages are available for three or more significant events (i.e., overbank flooding) that span more than a 25-year period of record and where hydraulic conditions have not changed appreciably since those events. Limited data on historical ice-jam stages are usually available at ungaged locations, and the SC may obtain these data from a variety of sources, such as community officials, resident recollections, newspaper accounts, high-water marks, tree damage or scars, vegetation trim lines, and disturbed bank material. Historical stages permit the SC to compute plotting positions and fit a frequency curve on probability paper. The SC should use Weibull plotting positions for this purpose. Additional guidance on graphical frequency analysis and the use of exceedance thresholds for ice-jam flooding is provided in *Hydrology of Floods in Canada—A Guide to Planning and Design* (Reference 23).

If the study or restudy reach includes a gaging station where historical ice jams have occurred, the SC can perform a stage-frequency analysis using the stage data at the gaging station. The SC should obtain the stage data necessary for this analysis from streamflow records published by the USGS and other agencies.

The annual-maximum stage can occur as the result of either a free-flow event or an ice-jam event. For the ice-jam events, the annual-maximum peak stage can occur at a different time than the annual-maximum peak discharge.

If detailed data are available, the SC may follow two approaches for the direct analysis of stage data: the annual-event series and the annual-maximum series. The SC can use the annual-event series approach when data are available for both the maximum peak stage during the ice-jam season and the maximum peak stage during the free-flow season for each year (two values per year). The SC can use the annual-maximum series approach when only data for the annual-maximum peak stages are available for each year. In both approaches, the SC must develop separate frequency curves for the ice-jam events and the free-flow events and then combine them to determine the percent chance that a given stage will be exceeded in a year. Weibull plotting positions are preferred for determining the individual stage-frequency curves. However, when there are more than 10 years of ice-jam or free-flow stages, the SC should fit a frequency distribution such as the Pearson Type III to the stage data or their logarithms to help define or extend the stage-frequency curve based on plotting positions.

I.4.1.1 Annual-Event Series

In the annual-event series, the SC should develop peak stages for the ice-jam season and for the free-flow season for each year of record. However, most often, the available data will not be sufficient to develop the annual-event series. In many years, only a single peak stage is reported.

To develop the annual-event series for these years, the SC must either estimate the peak stage for the missing season or, preferably, determine the peak stage through a search of the historical streamflow records. Estimation of the peak stage is not recommended because this introduces uncertainty in the analysis, particularly when estimating the missing ice-jam stages. Even though a search of historical streamflow records is usually time consuming, the SC should use this approach for developing the complete annual-event series.

For the annual-event series, stage-frequency curves are computed for each season and combined using the following equation:

$$P(s) = P(si) + P(sq) - P(si) * P(sq) \qquad (1)$$

where

P(s) = Probability of the annual-maximum stage exceeding a given stage "s" in any year, by either type of event

P(si) = Probability of the annual-maximum stage exceeding a given stage "s" in the ice-jam season (not all events in the ice-jam season will necessarily be affected by backwater from ice)

P(sq) = Probability of the annual-maximum stage exceeding a given stage "s" in the free-flow season

P(si) * P(sq) = Joint probability of the annual-maximum stage exceeding a given stage "s" in any year from both types of events

For the annual-event analysis, the SC should determine a peak stage for each season each year and combine the seasonal frequency curves assuming the two populations are independent of one another. Use of Equation 1 is not appropriate if the two populations are not independent, if it is impossible to compile an annual-event series, or if it is impossible to segregate the peak stages into populations based on distinct hydrologic causes. When this condition cannot be met, the SC should recommend and receive approval for an alternate approach that uses only the annual maximum peak stages in the frequency analysis.

I.4.1.2 Annual-Maximum Series

In the annual-maximum series, the SC identifies the annual peak stage in each year of record as resulting from either an ice-jam or free-flow event. The SC should then develop a stage-frequency curve using all annual-maximum stages that are ice-jam events and a separate stage-frequency curve using all the annual-maximum stages that are free-flow events. Each frequency curve is called a "conditional-frequency curve."

The ice-jam conditional-frequency curve is "conditioned" in the sense that only annual-maximum peak stages that are ice-jam-related are used in the frequency analysis. To obtain the probability of an ice-jam event exceeding a given stage "s" in any year, the SC should multiply the exceedance probabilities from the conditional-frequency curve by the fraction of time that ice-jam events produce annual-maximum peak stages.

The free-flow conditional-frequency curve is "conditioned" in the sense that only annual-maximum peak stages that are free-flow events are used in the frequency analysis. To obtain the probability of a free-flow event exceeding a given stage "s" in any year, the SC should multiply the exceedance probabilities from the conditional-frequency by the fraction of time that free-flow events produce annual-maximum peak stages.

The seasonal-frequency curves so computed are then combined using Equation 2 to obtain the probability of the annual-maximum stage exceeding a given stage "s" in any year due to either a free-flow or an ice-jam related event.

For the annual-maximum series, stage-frequency curves are computed for each season and combined using the following equation:

$$P(s) = (P(s) \mid s = \text{free-flow event}) * P(s = \text{free-flow event}) + (P(s) \mid s = \text{ice-jam event}) * P(s = \text{ice-jam event}) \qquad (2)$$

where

P(s)= Probability of the annual-maximum stage exceeding a given stage "s" in any year, by either type of event

(P(s) | s = free-flow event) = The conditional probability of the annual-maximum stage exceeding a given stage "s" in any year, when only free-flow events that are annual-maximum peak stages are used in the analysis

(P(s = free-flow event) = The fraction of years for which the annual-maximum peak stage was a free-flow event

(P(s) | s = free-flow event) * P(s = free- flow event) = The joint probability of the annual-maximum stage exceeding a given stage "s" in any year and the seasonal free-flow event is an annual maximum

(P(s) | s = ice-jam event) = The conditional probability of the annual-maximum stage exceeding a given stage "s" in any year, when only ice-jam events that are annual-maximum peak stages are used in the analysis;

P(s= ice-jam event) = The fraction of years for which the annual-maximum peak stage was an ice-jam event

(P(s) | s = ice-jam event) * P(s = ice-jam event) = The joint probability of the annual-maximum stage exceeding a given stage "s" in any year and the seasonal ice-jam event is an annual maximum

I.4.1.3 Summary

Equations 1 and 2 provide two different approaches for combining stage-frequency curves when stage data are directly available, when stage data are determined by the indirect approach described in Subsection I.4.2, or for a combination of the two approaches. For example, the SC can use Equation 1 where limited historical stage data are available for ice-jam analysis and where the stage data for free-flow conditions are determined using the indirect approach. The SC can estimate the probability of the annual-maximum stage exceeding a given stage "s" in any year from an ice-jam event (P(si)) from limited stage data such as three events occurring over at least a 25-year period. As discussed earlier in this appendix, the FMPCC should perform a graphical analysis using Weibull plotting positions, and combine the probability (P(si) with the free-flow probabilities (P(sq)) using Equation 1. The SC can determine the free-flow probabilities (P(sq)) using discharge-frequency analysis for the free-flow season and standard hydraulic modeling procedures as described in Subsection I.4.2.

Equation 2 is more appropriate for directly computing stage-frequency curves for study or restudy reaches where detailed information is available, such as at gaging stations. This approach requires the fraction of time that annual-maximum stages are caused by either ice-jam or free-flow events and uses just the annual-maximum stages for the two types of events. This information is usually not available or easy to determine for ungaged locations.

The SC should use the direct approach rather than the indirect approach as discussed below because the joint probabilities of various hydrologic and hydraulic factors (e.g., discharges, ice volumes, ice thickness) are inherently included in the frequency analysis. However, sufficient data are not often available for direct analysis or when hydraulic conditions in the study or restudy reach are different from gaging stations located upstream or downstream of the reach. In those instances, the SC should use the indirect approach.

I.4.2 Indirect Approach

I.4.2.1 Assumptions

The SC may use the indirect approach to ice-jam stage-frequency analysis where available data are insufficient to establish a stage-frequency distribution directly. This approach makes use of several assumptions:

- Ice-jam stage frequency is a function of ice-jam season-discharge frequency.
- Ice jams are of the breakup type.
- Ice jams are of the stationary type.
- For all jams, the ice thickness will be given by the equilibrium relationship developed by Pariset et al. (Reference 24), and the stage-discharge relationship will be determined by adjusting the standard step-backwater technique for flow under an ice cover of equilibrium thickness.

- For grounded-type jams, the stage-discharge relationship at the point of ice-jam formation will be that resulting from complete or nearly complete blockage of the normal channel, with flow being carried in the overbank floodplain areas.

I.4.2.2 General Procedures

To apply the indirect approach, certain procedures are used. These procedures are discussed below.

The SC should establish a free-flow stage-frequency distribution for each cross section by using standard backwater modeling to establish stage-discharge relationships. Usually, the four standard (10-, 2-, 1-, and 0.2-percent-annual-chance) discharges will provide the SC with sufficient points to establish the stage-frequency curve for each cross section on normal probability paper.

The SC should separate the water year into an "ice-jam season" and a "free-flow season" based on the historical occurrence of ice jams in the region and, in particular, in the stream under study. The season should encompass the period when breakup-type ice jams normally occur and will likely vary with the latitude and elevation of the stream being studied. Ice jams tend to be associated with one of the seasonal peak flows because ice jams typically form during rises in river stage that break up the ice sheet.

Where peak flow data are available at gaging stations, the SC should perform discharge-frequency analyses for the ice-jam and free-flow seasons using procedures described in Bulletin 17B (Reference 6). If the logarithms of the peak-flow data do not fit a Pearson Type III distribution, then other frequency distributions or the appropriate plotting position formulas can be used for this purpose. The reasons for deviating from Bulletin 17B procedures should be documented.

For ungaged streams, the SC should establish seasonal discharge-frequency relations by performing a regional analysis of seasonal flows for the gaged streams in the region. Usually, the establishment of regional seasonal discharge-drainage-area relations will be sufficient for this purpose. The SC should then use standard hydraulic techniques to establish corresponding stage-frequency curves for each cross section in the reach where ice jams are to be considered. Usually, the analyses of the standard percent chance of exceedance used in an FIS (i.e., 10-, 2-, 1- and 0.2-percent-annual-chance) will be sufficient to establish the stage-frequency curves. For ice-jam analysis, this is typically accomplished using the ice-cover option in the HEC-2 hydraulic program. This option takes into account the hydraulic aspects of flow under ice, such as a reduction in flow area, increased wetted perimeter, and ice roughness.

The inputs required to use this option include the normal HEC-2 input, the thickness of the ice in the channel and overbanks, Manning's "n" value for the underside of the ice cover, and the specific gravity of the ice. The SC should refer to "Analysis of Flow in Ice Covered Streams Using Computer Program HEC-2" (Reference 25) on the use of this option. The recommended ranges for "n" values are from 0.015 to 0.045 for unbroken ice and from 0.04 to 0.07 for ice jams. The specific gravity of normal ice is approximately 0.92 and is the recommended value for this analysis. Where major floods are caused by ice jams, the assumption of equilibrium ice thickness is probably reasonable because sufficient upstream conditions exist to generate the ice volumes needed. Unless there is strong evidence to the contrary, the ice thickness used in the analysis should be the approximate equilibrium thickness as defined by Pariset et al. in “Formation of Ice Covers and Ice Jams in Rivers” (Reference 24). Where equilibrium ice thickness is not appropriate, the SC should justify the thickness used in the analysis.

The SC should calibrate for floating-type jams by assuming equilibrium ice thickness at the location where the ice-jam stage-frequency curve is needed and use a combination of discharge, equilibrium ice thickness, and roughness that would correspond to that stage. The SC should calibrate grounded-type jams by assuming complete blockage of the main channel at the point of obstruction, with equilibrium ice thickness, discharge, and roughness that would correspond to that stage. This will permit the SC to use the HEC-2 ice cover option to estimate corresponding ice jam stages upstream or downstream of the point where historical data are available.

The SC should document that grounded-type ice jams have occurred historically before grounded-type jam behavior is assumed. Grounded-type jams may occur at confined sections, such as bridges, and at shallow sections. The hydraulic analysis assumes that a high percentage of the normal flow area of the channel (or bridge) is obstructed and that most of the flow is in the overbank areas.

At the point of obstruction, the SC should use an actual or hypothetical bridge section to permit the special bridge routine to facilitate the analysis. The SC should then adjust the low chord of the bridge (HEC-2 variable ELLC) and the net flow area (HEC-2 variable BAREA) to achieve different degrees of blockage of the main channel. The SC should normally assume between 95- and 100-percent blockage of the main channel unless sufficient evidence exists to support another assumption. In that case, the SC should document and justify the alternative. Upstream from the site of grounding, the SC should assume the equilibrium ice thickness, as computed according to the Pariset formulation (Reference 24), unless alternative thicknesses can be justified.

The SC should establish a stage-frequency curve for the ice-jam and the free-flow events by plotting the stages from the HEC-2 analyses at each cross section for the 10-, 2-, 1- and 0.2-percent-annual-chance floods on normal (or log-normal) probability paper and drawing smooth curves through these points.

Not every flood event during the ice-jam season is effected by ice. If sufficient ice-jam data are available, then the SC should incorporate the fraction of time that ice-jam season peak stages are affected by ice in the analysis. If the discharge-frequency relation in the ice-jam season is independent of ice conditions, then the 10-, 2-, 1- and 0.2-percent-annual-chance flood discharges are essentially the same for those years when ice jams occur and when they do not occur. Under these conditions, the SC should develop water-surface profiles for ice-affected and free-flow conditions in the ice-jam season. A modified version of Equation 1 for combining the stage-frequency curves is as follows:

$$P(s) = [P(sw)*P(si\text{=ice-jam event}) + P(so)*P(si\text{=free-flow event})] + P(sq) - [(P(sw)*P(si\text{=ice-jam event}) + P(so)*P(si\text{=free-flow event})) * P(sq)] \quad (3)$$

where P(s) and P(sq) are as defined in Equation 1

P(sw) = Probability of exceeding a given stage “s” in the ice-jam season developed using the discharge-frequency relationship for the ice-jam season and ice-affected hydraulics

P(si=ice-jam event) = Fraction of years during the ice-jam season that peak stages are affected by ice jams

P(so) = Probability of exceeding a given stage “s” in the ice-jam season developed using the discharge-frequency relationship for the ice-jam season and free-flow hydraulics

P(si=free-flow event) = Fraction of years during the ice-jam season that peak stages are free-flow events

The assumption in Equation 3 is that the conditional distribution of peak discharges for the ice-jam season is the same for ice-affected and free-flow conditions. If ice jams only occur when peak discharges are large or, conversely, if large peak discharges do not occur under free-flow conditions, Equation 3 is not applicable.

I.4.2.3 Summary

For the indirect approach, the SC should obtain the composite stage-frequency curve for the various percent-chance-exceedance floods at each cross section by combining the free-flow and ice-jam stage-frequency curves using Equations 1, 2, or 3, depending on the data and analysis procedures used in establishing the discharge-frequency relationship. The various conditions are summarized as follows:

- If the discharge-frequency analysis was performed using the annual-event approach (two discharge values per year), the SC should use Equation 1 to combine the ice-jam and free-flow stage-frequency curves. Equation 1 also applies for combining the stage-frequency curves if regional seasonal discharge-drainage-area relations are used to determine the discharge-frequency curves. Seasonal discharge-frequency curves developed in this manner represent the probabilities of the annual-maximum discharge exceeding a given discharge value during either the ice-jam or free-flow season. These exceedance probabilities are not conditioned or related to the fraction of time that the annual-maximum discharges are either ice-jam or free-flow events; therefore, the conditional-frequency approach of Equation 2 is not appropriate.
- If the SC based the discharge-frequency estimates of the 10-, 2-, 1- and 0.2-percent-annual-chance floods solely on annual-maximum discharge events, Equation 2 would be appropriate for combining the stage-frequency curves resulting from the HEC-2 analysis. This implies that the discharge-frequency curves used for this analysis are based on either ice-jam or free-flow annual-maximum discharges and that these frequency curves have NOT been adjusted for the fraction of time that the ice-jam or free-flow events are annual maximums.
- If the discharge-frequency relationship during the ice-jam season is the same under ice-affected and free-flow conditions and sufficient ice-jam data are available, the SC should use Equation 3 to account for the fraction of time that the peak stages in the ice-jam season are actually affected by backwater from ice.

I.5 Presentation of Results

I.5.1 FIS Report

The information the SC should include in the main body of the FIS report or as an additional subsection at the end of the FIS report is discussed below.

- Section 2.3 should include a discussion of historic ice jam.
- Section 3.1 should include a discussion of any discharge-frequency analysis for the ice-jam season, if used, and the statistical treatment of stage-frequency analysis for the ice-jam and non-ice-jam events. The historical data used in the analyses should be referenced in the discussion along with its source and how it was used. The Summary of Discharges table should be based on analysis of the full year and footnoted to that effect.
- Section 3.2 should include a discussion of how free-flow and ice-jam stages were computed and whether stages were computed directly from stage-frequency analyses or indirectly analyzed. The approximate channel blockage and ice thickness assumed, if used, should be discussed. The relationship of the computed ice-jam stages to historic floods should be discussed. An example of stage-frequency curves for combined floods should be provided for the point of obstruction, or a representative cross section within the community should be provided if the former is outside the corporate limits. The discussion should also indicate that floodways were computed only for free flow conditions.
- The "Regulatory" column of the Floodway Data Table should be prepared using the 100-year flood elevations established from the composite ice-jam and free-flow season stage-frequency curves and footnoted to that effect. All other columns in the Floodway Data table should be based on the 1-percent-annual-chance floodflow conditions.
- The Flood Profiles shown in the FIS report should be based on the elevations established from the composite ice-jam and free-flow stage-frequency analysis.

I.5.2 Maps

The SC and FMPCC shall develop the information shown on the FIRM based on the elevations established from the composite ice-jam and free-flow stage-frequency analyses performed at each cross section. Regulatory floodways shall be established and plotted based on the base flood discharges and hydraulics assuming free-flow conditions. The SC may indicate the lateral extent of a major historic ice jam on the work map if it is well documented, does not hamper interpretation, and is appropriately annotated as such.

References

1. Federal Emergency Management Agency, Federal Insurance Administration, *Flood Insurance Study Guidelines and Specifications for Study Contractors,* March 1993.

2. Federal Emergency Management Agency, *Document Control Procedures Manual*, October 1993.

3. Federal Emergency Management Agency, Federal Insurance Administration, FIA-12, *Appeals, Revisions, and Amendments to Flood Insurance Maps: A Guide for Community Officials*, December 1993.

4. Federal Emergency Management Agency, FEMA Instruction 8400.1.

5. U.S. Postal Service, Domestic Mail Manual.

6. U.S. Department of the Interior, Geological Survey, Interagency Advisory Committee on Water Data, Office of Water Data Coordination, Hydrology Subcommittee, Bulletin No. 17B, “Guidelines for Determining Flood Flow Frequency,” September 1981, Revised March 1982.

7. Federal Emergency Management Agency, “Procedures for Collecting Depositing, and Reporting Fees Under Part 72 of the NFIP Procedures,” updated.

8. Federal Emergency Management Agency, “Procedures for the Administration of FEMA’s Fee-Charge System,” updated.

9. Federal Emergency Management Agency, FEMA Manual 5200.1, *Correspondence*.

10. Federal Emergency Management Agency, *Congressional Correspondence Handbook*.

11. Federal Emergency Management Agency, Modernizing FEMA’s Flood Hazard Mapping Program: A Progress Report.

12. Federal Emergency Management Agency, Q3 Flood Data Specifications.

13. Federal Emergency Management Agency Federal Insurance Administration, *Standards for Digital Flood Insurance Rate Maps*, February 1990.

14. Federal Emergency Management Agency, *Methodology for Adding Horizontal Control to Flood Maps*.

15. Federal Emergency Management Agency, *FEMA Digital Line Graphs and Flood Risk Directory Production Procedures and Appendixes*, October 1991.

16. U.S. Department of the Interior, Coastal Barriers Study Group, *Report to Congress: Coastal Barrier Resources System*, *Recommendations for Additions to or Deletions from the Coastal Barrier Resources System*, 1988.

17. "Federal Emergency Management Agency Guidelines and Specifications, Existing Data Studies," dated September 2, 1982.

18. "Policy for Implementation of Printing FIS Report Texts by Volumes," dated October 16, 1984.

19. Federal Emergency Management Agency, Federal Insurance Administration, *Guide for Preparing Technical Support Data Notebook*. May 1989, Revised January 1990.

20. Federal Emergency Management Agency, Federal Insurance Administration, FAN – An Alluvial Fan Flooding Computer Program User's Manual and Program Disk, September 1990.

21. Alluvial Fan Flooding (Committee on Alluvial Fan Flooding; Water Science and Technology Board; Commission on Geosciences, Environment, and Resources; National Research Council), National Academy Press, Washington, DC, 1996.

22. U.S. Army, Cold Regions Research and Engineering Laboratory, Technical Note, "Methodology for Ice Jam Analysis," D.J. Calkins, October 1980.

23. National Research Council of Canada, *Hydrology of Floods in Canada—A Guide to Planning and Design*, Ottawa, Ontario, 1989.

24. E. Pariset, R. Hausser, and A. Gagnon, "Formation of Ice Covers and Ice Jams in Rivers," *Journal of the Hydraulics Division, American Society of Civil Engineers*, November 1966.

25. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "Analysis of Flow in Ice Covered Streams Using Computer Program HEC-2," February 1979.